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OF

WEYMOUTH, PORTLAND,

AND

COAST OF DORSETSHIRE,

FROM SWANAGE TO BRIDPORT-ON-THE-SEA:

WITH NATURAL HISTORY AND ARCHÆOLOGICAL NOTES.

BY ROBERT DAMON, F.G.S.,
MEMBER OF THE IMPERIAL NATURAL HISTORY SOCIETY OF MOSCOW, ETC.

NEW AND ENLARGED EDITION.

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LONDON: EDWARD STANFORD, 55, CHARING CROSS, S.W.
1884.

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PREFACE TO SECOND EDITION.

SINCE the issue of the First Edition increased attention has been given to the Geology of the coast of Dorsetshire; especially in the contributions of Messrs. Blake and Hudleston, and Professor Prestwich, which in part have been embodied in the present volume.

Elementary and explanatory notes are given for the use of those young in the study of the science.

A description of the geological formations of Swanage and Bridport, the two extremes of the district under consideration, is for more convenient reference placed towards the end.

The Geological Survey of this district was almost entirely made by Mr. Henry W. Bristow, Senior Director of the Geological Survey of Great Britain. To him I am greatly indebted for a final revision of the work. Mr. W. Topley, of the Survey, has also kindly given much assistance, as have also Messrs. G. Sharman and E. T. Newton with the lists of Fossils. Mr. Etheridge has favoured me with the Bridport portion of his unpublished sections of the Oolite rocks of England.

The works I have consulted are necessarily very numerous, and to their respective authors I acknowledge my great obligations.

To the above and other friends, who have kindly responded to my inquiries for information, my sincere thanks are rendered.

R. DAMON.

WEYMOUTH, *October* 1884.

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"On the Kimeridge Clay of England." By the Rev. J. F. Blake, F.G.S. 'Quart. Journ. Geol. Soc.,' vol. xxxi. p. 196 (1875).

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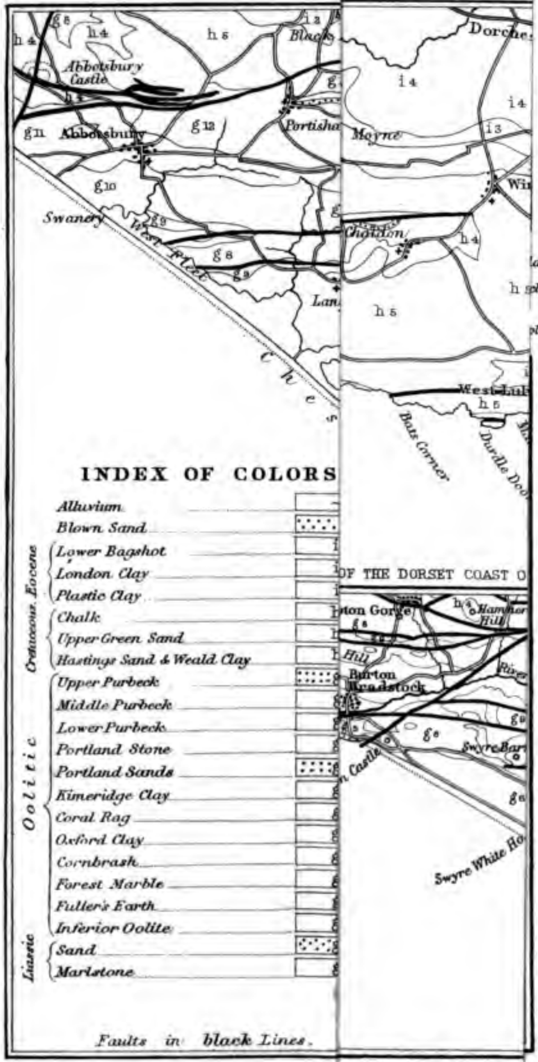

, Edward Stanford

GEOLOGY

OF

WEYMOUTH, PORTLAND, AND COAST OF DORSETSHIRE.

INTRODUCTION AND PHYSICAL FEATURES.

THE intelligent observer of the varied features presented in the region under consideration needs hardly to be reminded that what is now dry land was once at the bottom of the waters; the question would rather be—When were the adjacent lands lifted from their ocean-bed and fashioned into their present form of island, hills, and valleys; and by what agency was this effected? When Geology was first studied, it was generally believed that the term "everlasting hills" conveyed a literal truth, and that they alone remained stable and immovable. It is now an established truth that the great ocean of the globe ever maintains approximately the same level, and that the changing relative position of land and water is due to instability of the former rather than of the latter. Such changes of the Earth's surface were considered as exclusively due to some paroxysms which attended its early history, but which have now altogether ceased, or which act only with a greatly diminished power. It is, however, thought by some that the same agencies continue in operation, and act with an equal degree of intensity, at the present, as at any previous time;* the elevated lands having

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* In accordance with this view is the terrible outburst of volcanic energy at Java (August 1883) which has so changed the physical geography of the region that the former charts are said to be useless for purposes of navigation, whole mountains being submerged, new islands formed, and plains sunk beneath the sea.

M. Élie de Beaumont affirms that a correspondence in the direction been raised to their present positions not so much by one or more mighty convulsions, as by the action of more gentle forces operating through long periods of time ; and that thus the solid portions of the Earth are being built up, while the wasting power of rivers, atmospheric agencies, and the ceaseless action of the sea, wear down those parts which are exposed to these influences.

If the north and west coasts of our Island were formed of the softer strata instead of the older and harder rocks, its geographical area would be rapidly diminishing. These opposing actions illustrate that cycle of decay and renovation, or "evolution," which the solid parts of the Earth undergo, and by which the balance of land and water is maintained. The waste that its exposed part thus undergoes is compensated for by the materials that are removed being rearranged at the bottom of the Sea, and which, after a period of repose, are again raised to the surface to form new land.

Of the wasting and denuding power of the sea this coast furnishes ample illustration. The Chalk and softer strata having readily

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of mountain ridges indicates correspondence in the direction of strata, i. e. all mountain chains raised during one period have the same course however remotely situated from each other, and in confirmation of his theory furnished a list of parallel systems already recognised: that of the Jurassic or Oolitic being W. 26° N. From this approximate uniformity in the direction of mountain ridges, he infers that the rotatory motion of the Earth has assisted in producing them.—Johnston's 'Physical Atlas,' 2nd edition, p. 2.

Some assert that the proximate cause is to be found in volcanic agency, inasmuch as the greater elevations on the Earth's surface coincide with the line of extinct and active volcanoes. As this question lies at the foundation of all geological theories, it is one for general and profound study. Sir W. Thomson, on mathematical grounds, claims for the Earth, as a whole, from the surface to the centre, an extreme degree of rigidity; he has applied to it the laws of cooling of a solid body by conduction, and believes that during its passing from a liquid into this state is the period during which important geological phenomena have happened.—('Trans. Royal Soc. Edin.,' vol. 23, p. 157.) Dr. Sterry Hunt and Prof. le Conte expressed somewhat similar views, viz.: "that the crust of the Earth has contracted through cooling, and by horizontal pressure has crushed together solid masses, forcing them up vertically."

Mr. Mallet differs only from the above high authorities in referring the heat from which volcanic energy is derived "to the mechanical work of crushing, produced by the more rapid contraction by cooling of the hotter yielded to its action, have been worn away in a greater degree than the harder Oolitic and other rocks. The different formations having thus yielded unequally, there have been formed curves, bays, natural arches, caverns, peaks, and insulated portions. Examples:—Durdle or Barn-door Cove, Man-of-War Cove, Stare Cove, Lulworth Cove, Worbarrow Bay, &c.

Where the south-west frontier of the Chalk first rose out of the sea cannot now be determined, but it must have been considerably in advance of its present line. Probably the entire bay of Weymouth has been formed by the action of the sea on the more yielding strata which once filled that area.

From Portland to the Land's End, where harder rocks prevail, the coast is more linear; but where the softer formations come in, the coast line recedes.

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material of the nucleus beneath." The Rev. O. Fisher, Author of 'Physics of the Earth's Crust,' though accepting the hypothesis of extreme rigidity for the globe, as a whole, considers that the cooling of a solid sphere cannot account for the inequalities nor for the compression of the crust (p. 269), but, as he writes in the 'Geological Magazine,' "the surface phenomena require that the cooled crust of the Earth [which he estimates at from 25 to 30 miles thick] should be far more rigid than what it rests upon. For instance, they require that the substratum should be sufficiently fluid to admit of the crust being shifted over it towards the mountain ranges; that it should likewise be in a condition to flow upwards into narrow chasms, and form igneous dykes, and to furnish the ejectments of volcanoes." . . . He also argues, from facts connected with the rising and sinking of the surface, that "if the substratum be as rigid as glass or steel, then the crust must be much *more* rigid than glass or steel; which is a *reductio ad absurdum.* If it be asked how it can remain liquid, under the pressure of between 20 and 30 miles of superincumbent solid rock, I answer that recent experiments have tended to show that igneous rocks are denser when melted, than when solid at the melting temperature."—("On the Rigidity of the Earth," by O. Fisher, 'Geol. Mag.,' Dec. 2, vol. x. p. 94, 1883.)

All the above authorities agree in referring the greater elevation of our existing mountain ranges to the Eocene and Miocene Periods.

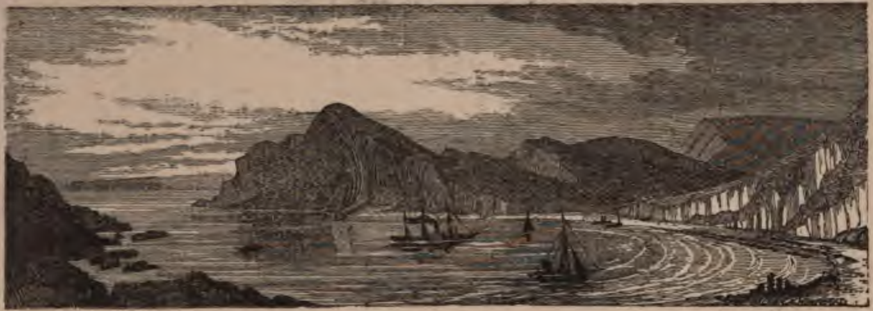

Fig. 1. Lulworth Cove.

An almost circular bay or basin, about five hundred yards in diameter; formed by the action of the sea on the receding Chalk. The rocks at the entrance on both sides of the cove, being composed of the Portland and Purbeck strata have been less affected. These last, as represented in Fig. 1, are highly inclined and contorted, while the Chalk and Wealden Beds are nearly vertical.

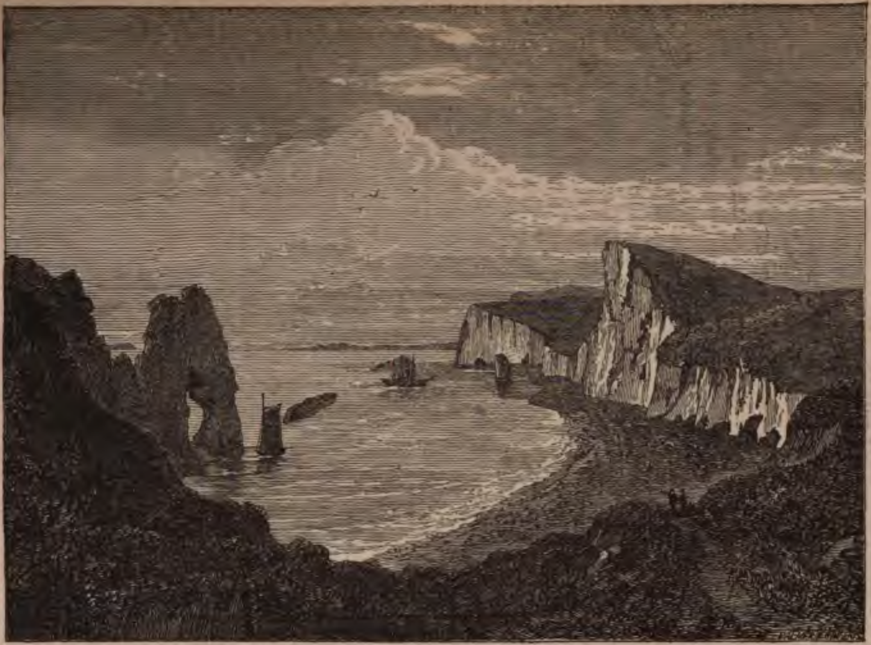

Fig. 2. DURDLE, OR BARN-DOOR COVE.

Durdle, or Barn-door Cove, half a mile west of Lulworth Cove. The most singular feature of this bay is the natural arch, known as the "Barn-door," formed in the Purbeck Limestone, and sufficiently high for a good-sized sailing-boat to pass through it. The Chalk strata composing the main cliff, on the north side, are almost vertical.

The effects of denudation are throughout the district very visible, the entire surface being more or less traversed with valleys of denudation and other hollows produced by this agency, the amount of which can be estimated not only from the absence of the superior formations of Greensand, Chalk, and Tertiaries, but from the almost complete disappearance of the vast mass of materials which once filled up these intervals.

These inequalities of the surface find an easy explanation in the theory now very generally accepted, viz. that as the land rose slowly out of the sea it became exposed to the denuding action of the waves and currents of the ocean, which in places may have removed each stratum as it rose to the surface, while in others temporary lakes were formed, the waters of which would eventually find for themselves an outlet. The action of atmospheric agencies on the upraised area would excavate valleys, such as the furrowed surface of the Chalk on the north-east of Weymouth; on the west there are the extensive valleys of Burton, Bridport, Chideock, and Charmouth, which all terminate at the sea.

As the former contents of these valleys must have been lodged in an adjacent sea, the shingle on the Weymouth shore, and the still more remarkable deposit of the Chesil Bank—composed as they are mainly of Chalk flints—may have been partially derived from these sources.

The distinguished Dr. Buckland, in reviewing the various proofs of a recent inundation of the Earth's surface, identified it with the waters of the Mosaic deluge; * but at a later period (1837) he considered the event in question as the last of the many geological revolutions which have been produced by violent irruptions of water, rather than by the comparatively tranquil inundation described in the inspired narrative.†

Though the order and relative positions of the various strata are well established, the series is necessarily incomplete, from there having been deposits of which no trace is preserved.‡ Neither are all the known formations present at or below any one part of the Earth's surface, a certain portion of dry land being always contemporaneous with the beds forming on the floor of the ocean.

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* 'Reliquiæ Diluvianæ,' 1824, p. 28.

† 'Bridgewater Treatise,' 2nd edition, vol. i. p. 94, *note*.

‡ The strata composing the crust of the Earth have been compared to

Table of British Strata, by H. W. Bristow, F.R.S., F.G.S.

	Subdivisions.	Origin.
Post Pliocene.	Blown Sand. Raised Beaches. Alluvium. Brick Earth. River Gravel. Cave Deposits. Glacial Deposits.	Various.
Pliocene.	Crags.	Marine.
Miocene ?	Leaf Beds and Lignite. Basalt-sheets of Antrim and N.W. Scotland.	
Eocene.	Fluvio-marine. Bagshot Beds. London Clay. Woolwich and Reading Beds, &c.	Freshwater. Estuarine and Marine.
Upper Cretaceous.	White and Grey Chalk. Upper Greensand. Gault.	Marine and Freshwater (Wealden).
Lower Cretaceous.	Lower Greensand. Wealden Beds, &c.	
Upper Oolitic.	Purbeck. Portland and Kimeridge.	Estuarine and Marine.
Middle Oolitic.	Coral Rag and Oxford Clay.	
Lower Oolitic.	Cornbrash. Forest Marble and Great Oolite. Stonesfield Slate. Inferior Oolite. Lias.	Marine.
Trias. Keuper.	Rhætic. New Red Marl, Sandstone, and Conglomerate.	Inland Seas.
Bunter.	Sandstone and Pebble Beds.	Salt Lakes.
Magnesian Limestone. Permian.	Red Marls and Magnesian Limestone. Red Marl, Sandstone, and Conglomerate.	Marine.

TABLE OF BRITISH STRATA—*continued.*

	SUBDIVISIONS.	ORIGIN.
CARBONIFEROUS.	Coal Measures. Millstone Grit. Yoredale Rocks. Mountain Limestone.	Terrestrial and Marine. (Partly Estuarine.)
DEVONIAN AND OLD RED SANDSTONE	Devonian Slates and Limestones. Old Red Sandstone, &c.	Marine. Freshwater.
UPPER SILURIAN.	Ludlow. Wenlock. Upper Llandovery.	Marine.
LOWER SILURIAN.	Lower Llandovery. Bala and Caradoc. Llandeilo. Arenig. Lingula Flags.	
CAMBRIAN.	Harlech Grits. Llanberis Slates.	Marine.
LAURENTIAN.	Gneiss of the Outer Hebrides, and N.W. Coast of Scotland.	Marine.

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the concentric layers of an onion, but the illustration, though instructive, is not strictly accurate, as no one stratum ever enveloped the entire globe.

"The most profound depths of the sea coincide nearly with the elevations on the Earth's surface, the average height of which is 9504 feet."—O. Fisher's 'Physics of the Earth's Crust,' p. 55.

From the top of Chimborazo to the bottom of the Atlantic, at the deepest place yet reached by the plummet, the distance in a vertical line is nine miles.—Maury's 'Physical Geography of the Sea,' p. 251, 2nd edition.

The greatest depth reached by the Challenger Expedition was 4575 fathoms or 27,450 feet.

In a lengthy memoir "On the missing Sedimentary Formations," by Dr. J. J. Bigsby ('Quart. Journ. Geol. Soc.,' vol. xx. p. 198), 150 gaps or blanks are recorded as arising from suspension or removal of

An Artesian Well at Kentish Town was sunk through the following formations:—

Feet.	
324	Tertiary Beds.
645	Chalk.
14	Upper Greensand.
130	Gault.

The Lower Greensand, Oolite, and Lias being absent, and the Gault reposing on Palæozoic rocks.

The strata of this district belong chiefly to the Oolitic group, so called from many, though not all, of its stone beds being composed of small roe-like particles, the nuclei of which are generally, as shown by the microscope, a fragment of shell or of some other organic body. The group of strata described as Oolitic in England is better known on the Continent as Jurassic, from the Jura Mountains being in part composed of beds equivalent to those of the Oolites of Great Britain, although often differing in their lithological character, the Oolitic rocks of the Jura being considerably harder.

In Great Britain the Oolitic series ranges from the coast of Dorsetshire through the centre of the country, to the coast of Yorkshire, and reappears in the north of Scotland, in Sutherlandshire and Skye. It is largely spread on the opposite coast of Normandy, where it offers a close resemblance to the corresponding strata of Dorset and Somerset. It prevails also in other parts of Europe, as in the vicinity of Moscow, where it rests on the Carboniferous Limestone, the intermediate formations being there wanting. Discoveries of fossil remains in India prove that the Oolite is also there represented, as in the Himalaya Mountains. Captain A.

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deposit by denudation, and other causes. Among other results, says the same Author, these absent deposits "yield us in the vast Laurentian spaces, European and American, the remarkable spectacle of the most ancient land known, witnessing itself little disturbed, for a length of time which no man can measure, the successive immersions and emersions going on around them, with all their strange and beautiful results. These gaps or blanks, by their magnitude and number, become a great feature in the Earth's crust, expressive of unity of design in time and space."—Bigsby, p. 233.

Gerard collected Ammonites of that formation 16,200 feet above the level of the sea.*

Sir John Richardson brought fossils from the Mackenzie River which were referred by Mr. Sowerby to the Oxford Oolite. The existence of Jurassic beds on the East Coast of Africa is also established.†

The Oolites yield the principal building-stones of the middle and south of England, and include the Purbeck, Portland, and Bath stones. Caen stone is similar to the Bath, and the celebrated lithographic stones are worked from the Upper Oolite of Solenhofen. The beautiful statuary marble of Carrara in Italy is considered to be an altered Oolitic limestone,‡ its crystalline texture, clear whiteness, and absence of fossils being due to the action of subterranean heat. In some parts of Italy, where Oolitic limestones abound, it is found that their texture resembles that of the Carrara Marble in proportion as they are altered by heat. Had the force which raised Portland from the bed of the sea been accompanied, as in the elevation of the Alps, with eruptive matter forcing a passage through the superincumbent strata, the Isle of Portland might also have yielded marble beds somewhat resembling those of Carrara.

The Oolite of Great Britain is perhaps at no one district more fully represented than in Dorsetshire.

The following formations, represented on the coast between Swanage and Bridport, are described in their ascending order:—

POST-TERTIARY.

Land Slips, Sea Waste, Atmospheric Débris.
Raised Beaches.
Sandstone Boulders, Druid or Sarsen Stones.
Chalk Flints, and Breccia.
Mammaliferous deposits.

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* 'Quart. Journ. Geol. Soc.,' vol. v. p. 290.

† 'Quart. Journ. Geol. Soc.,' vol. xv. p. 17.

‡ Since the above was written, other views have been expressed: one that the Carrara Marble is of Liassic age; others that the formation should be assigned to the Carboniferous or some other Palæozoic period. —'Quart. Journ. Geol. Soc.,' vol. xxiv. p. 41, and 'Geol. Mag.,' July 1876. The Geological Surveyors of Italy consider it to be Triassic.

Tertiary.

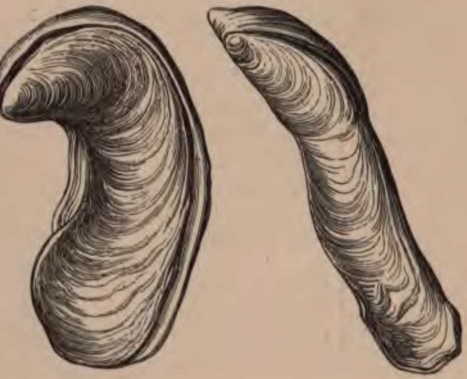
Newer Pliocene. (Bone caverns.)
Eocene.
Plastic Clay, or Woolwich and Reading Beds.

Secondary.

Cretaceous	Upper White Chalk with flints.
	Lower White Chalk.
	Chalk Marl.
	Upper Greensand.
	Gault.
	Wealden Beds.
Upper Oolite ..	Purbeck Beds.
	Portland Stone.
	Portland Sand.
	Kimeridge Clay.
Middle Oolite ..	Upper Calcareous Grit.
	Coral Rag (Coralline Oolite).
	Lower Calcareous Grit.
	Oxford Clay.
Lower Oolite ..	Cornbrash.
	Forest Marble.
	Fullers' Earth.
	Inferior Oolite Limestone and Sands.

FULLERS' EARTH.* (Characteristic Fossil.)

Fig. 3. (Natural Size.)



Ostrea acuminata, Sow. (Aberrant forms.)
From the Fullers' Earth, Langton, Weymouth.

Usually a grey or greenish-coloured clayey bed with layers of "Fullers' Earth."* Its nearest point to Weymouth is a small portion of the cliff at Langton, on the shore of the Fleet, five miles west from Weymouth. It reappears at Abbotsbury, and from thence extends without interruption along the coast to Burton Castle, 2 m. east of Bridport Harbour, where it attains its maximum development. Its distinguishing fossil is a small elongated oyster, *Ostrea acuminata*, which is generally abundant. At Langton the cliff is little else than a mass of this one species. The site of this singular accumulation is the cliff immediately below the Coastguard station. Though as many as 100 species of fossils are referred to the "Fullers' Earth" formation, very few besides *O. acuminata* are found here.

Prof. R. Tate considers, from Palæontological evidence, that the Fullers' Earth should be referred to the top of the Inferior Oolite and not to the base of the Great Oolite. ('Quart. Journ. of Science,' Jan. 1870.)

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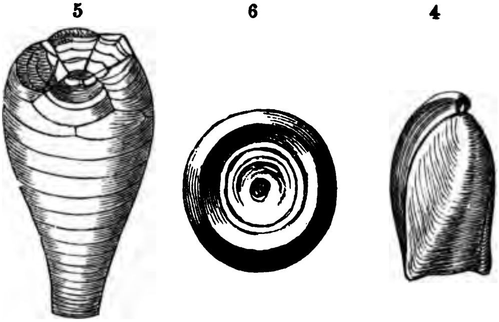
* From its property of absorbing grease, it was once largely used by cloth manufacturers in the operation known as "Fulling."

FOREST MARBLE. (Characteristic Fossils.)



4. *Terebratula digona*, Sow. Natural size.
5. *Apiocrinites rotundus*, Miller. Slightly reduced. (Pear Encrinite.)
6. Section of ditto.

} Weymouth.

The Forest Marble comprises both layers and blocks of limestone, divided by thin seams of clay and calcareous bands. The limestone portion, or that commonly known as the " Forest Marble," is in great part composed of comminuted shells, *Echinidæ*, and other drift or tidal deposits, with prints, and trail-marks of molluscs, worms, &c. It is so fissile and slaty as to supply roofing-, fencing-, and flag-stones for the villages near which the stone occurs.*

In Wychwood Forest, Oxfordshire, a portion of it assumes a crystalline texture, and when worked and polished, forms the coarse marble from which the formation takes its name. Bivalve shells are most common in the thick beds, univalves in the thinner beds. *Apiocrinites rotundus*, with the upper arms and lower stem complete, and 15 to 20 inches in length, is a singular and beautiful crinoid. An additional interest has been given it in the discovery by the " Porcupine Expedition," at the depth of 2435 fathoms, of a living example of the "Apiocrinite" type, hitherto supposed to be extinct.

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* Referring to this formation in Dorsetshire, Mr. Conybeare remarks that it seems more probable that the great Oolite passes into the fissile character of Forest Marble, than that the Forest Marble (generally a subordinate bed only) should here attain such a disproportionate thickness, and the Great Oolite itself be absent.—'Outlines of Geology,' p. 205.

Its horizontal extension here is considerable: rising from beneath the Cornbrash at Radipole and Nottington, it extends westwards to the coast at Abbotsbury, with an average width of 2 miles, and a thickness of 500 feet. Organic remains are generally abundant, many of the thin stony beds being composed of fragmentary shells. The best-preserved specimens are from the seams of clay which alternate with the stony beds. The waved and wrinkled appearance, so characteristic of the Forest Marble, answers to examples offered at the present day by the furrowed surface of sand exposed at low tides on a flat and shallow shore. Strata presenting such an appearance were probably likewise formed on a shallow shore. This analogy is rendered still closer by the beds being composed of rolled fragments of *shells, corals, echini*, and *crustacea;* and above all by the frequent impression of small footsteps, apparently of crabs and annelids which frequented the shore when it became exposed by the ebbing tide.

Dr. Sorby has detected, by microscopical examination, that the tidal action which accompanied the deposition of the Forest Marble was

Ebb	from S. 33° East.
Flow	,, S. 35° West.

By the thinning out of the strata, and the disappearance of certain genera of shells and other organisms, which required a greater depth of sea, and the occurrence of others that are littoral, the position of the ancient coast-line may be inferred.

LIST OF FOSSILS from a small quarry of Forest Marble, near the higher mill at Radipole, where we meet with the following section:—

a. Soil—1 foot.

b. Whitish clay, which towards the middle and lower part contains flags of hard bluish limestone, frequently covered with shells, both whole and fragmentary—this latter condition being characteristic of Forest Marble—12 feet.

c. Solid beds of stone, forming the bottom of quarry, and probably extending to much greater depth—4 feet.

List of Fossils found in this Quarry:—

Avicula costata, Sow.
Lima duplicata, Sow.
Pholadomya Heraulti, small var., Ag.
Pecten hemicostatus (*vagans*) Lyc. and Morris.
Trigonia pullus, Sow.
Rhynchonella obsoleta, L.
  „ *varians*, Schloth.
Terebratula digona, Sow.—abundant.
  „ *coarctata*, Park.
  „ *intermedia*, Sow.
  „ *perovalis*, Sow.
**Apiocrinites rotundus*, Miller.
Stems of *Pentacrinus* and *Lignite*.

A quarry has lately been opened in a field near the Farm House at the end of Cold Harbour Lane, one mile north of the Upper Mill. This section, which exposes a fault, offers from 15 to 20 feet of grey and light-coloured clays, resting on coarse fissile stone, which in some parts is chiefly composed of small shells and portions of shells and corals, with worm-tracks and tidal marks.

List of Fossils found here:—

Avicula costata.
Lima duplicata.
Ostrea Sowerbyi.
Pecten hemicostatus.
Rhynchonella obsoleta.
  „ *varians* (media).
Terebratula digona.
  „ *intermedia.*
Eulima, *Cerithium*, *Turbo* and other small univalves.
Apiocrinites rotundus.
Pentacrinus, stems.
Fragments of *Lignite.*

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* The stratum known as the "Bradford Clay" near Bath, and once famous for its rich deposit of the "Apiocrinus" or Pear Encrinite, is but a sub-formation dividing the Forest Marble from the Great Oolite. Its separate occurrence cannot be established in this district, though its prevailing fossil is sparingly distributed.

FOREST MARBLE.—NOTTINGTON.

A village 3 miles north of Weymouth, in a quarry (since enclosed), where the Forest Marble was quarried, the section was as follows:—

a. Soil—1 foot.
b. Clay—5 feet.
c. Alternately layers of Clay and soft sandy Stone—4 feet.
d. Clay—2 feet.
e. Stone—2 feet.
f. Blue Clay—1 foot 3 inches.
g. Good Stone, bluish, shelly, crystalline, hard, less fissile than the stony beds of the Forest Marble usually are—7 feet.
h. Blue Clay—bottom of quarry.

LIST OF FOSSILS—

Avicula costata.
Lima duplicata.
Myacites decurtatus.
Ostrea Sowerbyi.
Rhynchonella varians.
Terebratula intermedia, abundant.
" *digona*, "
Pecten hemicostatus.
Apiocrinites rotundus.

Small shells, &c., on flagstones.

This list will doubtless be applicable to any other section that may be opened in the vicinity: the opening and subsequent closing of such quarries being of frequent occurrence.

FOREST MARBLE.—LANGTON HERRING.

In a quarry between the village and the Coast-guard station a good section is offered, which differs from that at Radipole:

a. Soil—1 foot.
b. Clay—1 foot 6 inches.
c. Stone, in layers one and two inches in thickness. Greyish when fractured, and composed in great part of comminuted shells—9 feet.
Bottom of quarry.

Fossils are numerous on the surface of the flagstones; chiefly of the genera *Pecten* and *Ostrea*, with portions of *Apiocrinites*.

Cornbrash quarries are close by.

The Forest Marble and Cornbrash formations, although in close proximity, are very dissimilar in lithological characters; the presence of the characteristic species of fossils figured will be found a further means of identification.

In a quarry of Forest Marble at Well Down, a little east of Abbotsbury, fossils are numerous, chiefly of the following species:—*Avicula costata*, *Ostrea Sowerbyi*, *Rhynchonella obsoleta*, *Terebratula digona*, *T. intermedia*, and *Hemicidaris*.

Organic remains, though so abundant in the Forest Marble of Wilts, including, besides Echinidæ and Mollusca, Fishes and Crinoidea, are in the Weymouth beds confined to a comparatively small number of determinable species.

CORNBRASH.

In immediate contact with the Forest Marble, with which it is generally associated, is the Cornbrash (so called from the stone breaking up or disintegrating into small rubble), which becomes well adapted for the growth of corn, and which yields, in comparison with other stonebrash lands, much better crops.*

* Analysis of the Cornbrash by Professor A. Voelcker:—

Carbonate of lime	89·195
Magnesia	0·771
Sulphate of lime	0·241
Alumina	2·978
Phosphoric acid	0·177
Soluble silica	1·231
Insoluble silicious matter	4·827
Alkaline salts (undetermined)	
	99·423

The agricultural capabilities of cornbrash lands may be judged from the rent-charge (in 1861) in the county of Gloucester, quoted by Professor Buckman, on "The Oolite Rocks of Gloucester and North Wilts," 'Quart. Journ. Geol. Soc.,' vol. xiv. p. 98.

1st.	Rent of Stonebrash,	inferior oolite,	from	7*s.* to 20*s.* the acre.
2nd.	„	great oolite,	„	14*s.* „ 25*s.* „
3rd.	„	Cornbrash,	„	20*s.* „ 40*s.* „

CORNBRASH. CHARACTERISTIC FOSSILS.

Fig. 6.

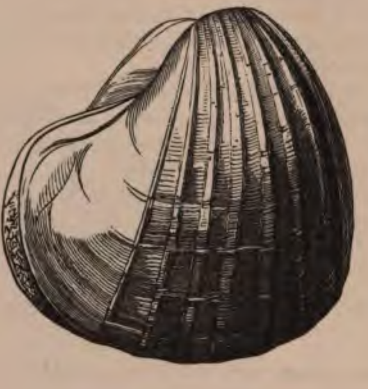


Fig. 7

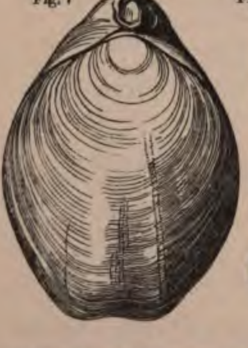


Fig. 8

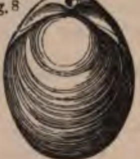


Fig. 10

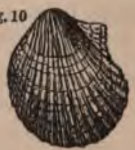


Fig. 9

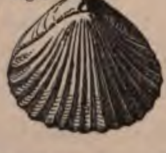
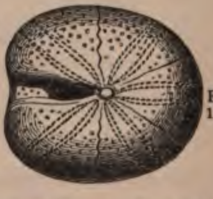


Fig. 10a.



6. *Pholadomya bucardium.* Ag. Reduced.
7. *Terebratula intermedia.* Natural size.
8. „ *obovata.* do.
9. *Rhynchonella concinna.* do.
10. *Avicula echinata.* Natural size.
10*a*. *Echinobrissus* (*Nucleolites*) *clunicularis.*

All from the Cornbrash, Weymouth.

It is a coarse rubbly limestone, of a grey or bluish colour, generally in flattish or lenticular masses, yielding stones seldom exceeding a foot in diameter, and of but little value as building-stone. Partings of brown and greyish clays alternate with the more solid beds. At Weymouth this formation is about forty feet in thickness.

Geologically considered, the Cornbrash is an unimportant formation, easily recognised by its organic remains, which are extremely numerous. Phillips, in the 'Geology of Yorkshire,' remarks that "it is not so much by the presence of particular species of fossils which are found in no other stratum, that the Cornbrash can be accurately identified, as by the occurrence together in it of some fossils which are repeated in rocks above, and several others which are found in those beneath." Confirmatory of this opinion, Professor Buckman observes that every fossil figured by Phillips, illustrative of Cornbrash, equally well illustrates the Inferior Oolite of Gloucestershire. The late esteemed Treasurer of the Dorset Nat. Hist. Soc., the Rev. H. H. Wood, gave considerable attention to the Cornbrash as developed in Dorsetshire, with what results may be seen from the following data:—

Professor Buckman, in the 'Quart. Journ. Geol. Soc.' vol. xiv. gives 71 species from Gloucestershire, exclusive of Cephalopods and Brachiopods (the latter very numerous). Mr. Whiteaves enumerates 76 species from the neighbourhood of Oxford; and Mr. Leckenby 136 species as occurring near Scarborough. "I do not (writes Mr. Wood) like to speak very positively, but I think I have nearly 180 species of Mollusca alone, from my own neighbourhood (Holwell, near Sherborne), and I am sure the list can be still further increased." * This interesting Collection may be seen in the Museum of the Sherborne Grammar School.

A section of the Cornbrash may be noticed near the second milestone on the road to Dorchester (the eastern termination of a zone about half a mile in width, passing through the villages of E. and W. Chickerell to the Fleet backwater), and in a narrower but almost parallel zone extending from Nottington through Tatton to Langton Herring. It is throughout characterised by the same fossil remains, chiefly bivalves, of which the Brachiopoda are the most numerous. The channel of the backwater near the village of Radipole has been formed through the Cornbrash. The low cliffs

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* 'Proc. of Dorset Nat. Hist. Soc.,' 1877

on either side are favourable points for examining this formation, the stony beds of which are highly charged with fossils. In an adjoining field the upper stratum has been opened for the purpose of quarrying stone for ballasting the adjacent railroad.

LIST of FOSSILS found in the Cornbrash, at Radipole:—

Fish-remains.
Crustaceæ.
Rhyncholites. (Sepia-beaks.)

Ammonites. Impressions.
Belemnites (?)

Actæon.
Cerithium.
Littorina.
Nerinæa.
Natica. Two species.
Serpula.

Avicula echinata, Sow.
Ceromya concentrica, Sow.
Cardium.
Corbula.
Goniomya literata, Goldf.
Lima duplicata, Sow.
Lucina.
Myacites decurtatus, Phil.
  „ *securiformis*, „
Modiola cuneata, Sow.
  „ *Lonsdalei*, Lyc.
Nucula.
Ostrea costata, Sow.
  „ *flabelloides*, Lam. (*Marshii*, Sow.).
  „ *Sowerbyii*, Mor. and Lyc.
  „ small flat species.
Pecten arcuatus, Sow.
  „ *hemicostatus*, Lyc.
Pholadomya bucardium, Ag. Common.
  „ *carinata*, „
Pholadomya (?)

Rhynchonella concinna, Sow.
„ *obsoleta*, Sow.
„ *tetrahedra*, Sow. (?)
„ *varians*, Schloth.
Terebratula globata, Sow.
„ *intermedia*, Sow.
„ *obovata*, „
„ *maxillata*, „
„ *perovalis*, „
Venus.

Holectypus depressus, Lam.
Echinobrissus (*Nucleolites*) *cluniculari*s, Llhwd.
*Pentacrinite.**

In a quarry at Buckland Yoleys many of the above species are met with.

Numerous other Quarries and road-cuttings in the Cornbrash may be seen in the neighbourhood, but the formation offers little variety, either zoologically or lithologically. The almost entire absence of Ammonites and other Cephalopods, so characteristic of the preceding and succeeding formations, deserves notice.

OXFORD CLAY.† (Additional Figures of Fossils. Supplement, Plates 1, 2, 3, 17, 18.)

The name of this formation is derived from its occurrence in the vicinity of Oxford, where it forms the substratum of the valley of the Isis. Dr. Buckland and Sir H. De la Beche estimated its thickness in this district at 300 feet.* The Geological Survey assigns to it a thickness of nearly 600 feet. It is closely associated in places (from the occurrence of "faults" and "slips") with the Kimeridge Clay. There is, however, no possibility of the two formations being confounded when any fossils are present: thus, the common flat oyster, *Ostrea deltoidea* (Fig. 31) marks the Kimeridge; the curved oyster, *Gryphæa dilatata* (Fig. 7, Plate III.), the Oxford Clay. This latter clay is generally of a dark-blue colour, though not uniformly so, its upper portion being sometimes brownish. Its boundary on the east of this district is marked by the conspicuous land of Ham Cliff, whence it runs conformable to and follows the course of the Coral Rag to its western termination at Abbotsbury; southward through Jordan Hill, Lodmoor, and Greenhill to Weymouth Harbour (its southern boundary); and proceeds westwards to the shore of the East Fleet. The displacement of strata in the Weymouth district is marked by the Oxford Clay being adjacent to the Coral Rag on the south, as it is to another belt of Coral Rag on the north, the intermediate distance being occupied by the Forest Marble and Cornbrash.

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* The major part of the Cornbrash fossils, being casts, are sometimes difficult to determine.

† L'Argile de Dives is the name for this clay on the opposite coast of Normandy.

The uniformity of the zoological character of the Oxford Clay in districts widely remote, is shown by the presence of the same species in Great Britain, Wurtemburg, Russia, and South Africa.

At Koroschovo, a suburb of Moscow, the Oxford Clay is distinguished for the number of its fossils. Here, in the bed of the "Moskwa," when the water is low, may be seen the prevailing species in great profusion.

The first vertical shaft of the long tunnel on the Dorchester Railway passes through the Oxford Clay; this part of the hill is 300 feet above the level of the sea: it follows therefore, that the Oxford Clay at Ridgway is but little short of that height above the Oxford Clay at Weymouth. As, at the period of its deposition, it formed a continuous and horizontal stratum, this portion must have been raised into its present anomalous position, viz. between the Wealden Beds on the south, and the Chalk and Greensand on the north, instead of the Cornbrash and Coral Rag. Its appearance between strata of so much later a period is so remarkable, that doubts were entertained

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With the help of a few children belonging to the village, a heap of fossils was soon made, but from which, at such a remote part, I could make only a small selection. *Belemnites Owenii*, and *Bel. hastatus* of the Oxford Clay of Britain were represented by *Bel. obsoletus* and *B. Panderianus* in extraordinary numbers. Ammonites with iridescent nacre, among which were *Am. Kœnigi*, *Leachii*, *catenulatus*, *ornatus*, &c. Brachiopods (so rare with us) together with other familiar fossils were also numerous.

The beds are less argillaceous than in England, being more of a black shale which in the summer pulverises into an impalpable dust.

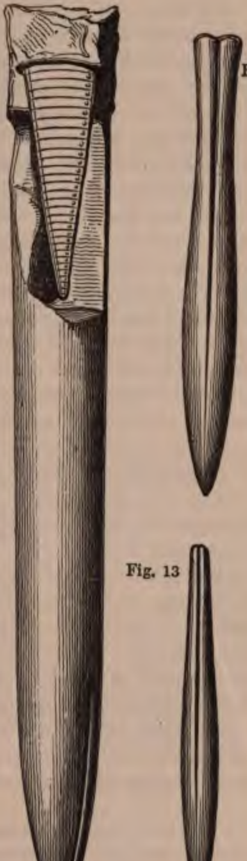
* "Memoir on the Geology of Weymouth," Trans. Geol. Soc. Ser. 2, vol. iv.

as to its identity, but the following list of fossils, nearly all of which are well-known Oxford Clay species, places it beyond doubt.*

Ammonites catena.
" *Lamberti.*
Astarte.
Anomia.
Modiola bipartita.
Myacites oblata, Sow.
Nucula.
Ostrea flabelloides, Lam.
Gryphæa dilatata.
Trigonia perlata.
Thracia depressa.
Pholadomya.

In reply to another attempt to account for the occurrence of the Oxford Clay in such an unlooked-for situation as a drift, Mr. Weston remarks:*

> 1. That the fossil bones found bear no marks of abrasion which would indicate their having been drifted.
>
> 2. That the Oxford Clay is of considerable depth; 60 feet having been reached without arriving at its termination.
>
> 3. That the vertical surface of the wall of Chalk is not consistent with the natural results of previous diluvial action in the localities under consideration.
>
> 4. Whence could the Oxford Clay have drifted? there being no exhibition of that bed in the neighbourhood at so high a level.



11. *Belemnites Owenii.* Pratt. Reduced.
12. " *hastatus.* Blain. Half nat. size.
13. " *gracilis.* Phillips. Nat size.
All from the Oxford clay, Weymouth.

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* 'Quart. Journ. Geol. Soc.,' vol. iv. p. 245.

The Rev. Osmond Fisher, who was residing in Dorchester during the construction of the Wilts, Somerset, and Weymouth Railway, contributed the following note on the complicated fault at Ridgway, in 'Barnes' Guide to Dorchester':—"The geologist will find an interesting object at the railway-cutting through Ridgway Hill. It was known to Buckland and De la Beche when they drew up their paper upon the Weymouth district, that there was a great fault, ranging nearly east and west, and following the southern escarpment of this range of hills, bringing beds of different ages, from the Oolites to the Greensand, into contact with the chalk. At that particular point, however, where the fault is laid open by the recent works, the phenomena are of a very unusual and complicated kind. The cutting displays a complete sequence of strata, from the lower part of the Portland beds, through the entire Purbeck series, to the Wealden clays and sands. But the singularity of the section consists in a portion of the Oxford Clay making its appearance between the Wealden beds, and where the fault cuts off the chalk. Having opportunities of watching the progress of the works, I was aware of the Oolitic clay appearing as long ago as 1846, when I found a specimen of *Trigonia* in the clay from the shaft; but when the cutting was commenced, *Gryphæa dilatata* occurred in plenty with portions of other fossils of the Oxford Clay, and I was convinced of the identity of the clay."

The Oxford Clay, like the Kimeridge, contains beds of inflammable shale, though of less strength than the latter. Our friend Mr. McNeil has in the course of his experiments lit his offices with gas obtained from the unctuous bituminous shale of the Oxford Clay.

Iron Pyrites* is largely diffused in this formation; frequently incrusting organic remains, of which there are examples in the numerous small Ammonites that occur in this neighbourhood, in which latter condition we have an illustration of its production by the decomposition of animal matter.† The sulphurous springs at

---

* An article of commerce worth about 15*s.* a ton, and yielding one-third sulphur and two-thirds iron. Its colour is different shades of brass-yellow, hence in these days of gold searching it has been mistaken for the precious metal. Iron pyrites is also largely used in the production of green vitriol and sulphuric acid (copperas and oil of vitriol).

† Mr. Pepys ('Trans. Geol. Soc.,' vol. i. p. 399) records the accidental discovery of the production of Iron Pyrites from the decomposition of the bodies of some mice, which had fallen into a pitcher containing several

Nottington and Radipole Spas, near Weymouth, derive their chemical character from the decomposition of this mineral in the alkaline sulphates of the shaly beds of the Oxford Clay. Disengaged gases are sometimes detected, arising from the same cause. At the old end of the Quay Wall of Weymouth Harbour a gas, from the Oxford Clay, rose to the surface, which burnt with a bluish flame.

Selenite, a crystallised form of sulphate of lime, produced by the action of decomposing iron pyrites upon the fossil shells, is abundant throughout this formation. Its ordinary form is a lenticular crystal, from one to three inches in length, soft, transparent, and easily splitting into thin plates or laminæ, when it is flexible like talc, a mineral substance found in the older formations.[*]

Septaria [†] are numerous throughout the Oxford Clay in the Radipole backwater, also at the Greenhill, where they have formed in successive layers. None present such beautiful markings as those met with at the first-mentioned spot. Cut into slabs and polished, they form suitable tops for fancy tables. Though locally

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quarts of a solution of iron that had remained unnoticed for a year. In these and other similar cases, the hydrogen evolved from the decomposition of the animal matter is considered to take the oxygen both from the sulphuric acid and oxide of iron, so that Iron Pyrites is formed.

[*] Selenite is one of the forms of sulphate of lime, whence plaster of Paris is derived. As fibrous gypsum it occurs in Derbyshire, where it is worked into various ornaments. As a soft chalky stone, there are inexhaustible beds in the neighbourhood of Paris. In the Island of Purbeck, blocks of gypsum are worked in the cliffs, and exported for making plaster of Paris. In its granular or more massive form it is better known as alabaster, which in Italy yields that well-known material which is turned in the lathe, and sculptured into figures and vases.

Scale of the relative hardness of minerals as adopted by "Mohs":—

1. Talc.
2. Gypsum (Selenite).
3. Calcite (carbonate of lime).
4. Fluor Spar.
5. Apatite.
6. Felspar.
7. Quartz (Rock Crystal).
8. Topaz.
9. Sapphire.
10. Diamond.

[†] Concretions formed round a nucleus, and composed of their clayey matrix and calcareous matter; the latter traversing the mass during their formation in veins, or septa, hence their name. The Septaria of the London Clay are, after being calcined and ground, made into Roman Cement.

termed "pudding-stone," they are essentially different from the conglomerate known by that name. The term, as applied to Septaria, is used to denote their form and structure; to the conglomerates of Hertfordshire, their composition, the latter being composed of gravel and flint pebbles in a silicious cement, so mixed as to suggest the above epithet.

The name *Turtle Stone* has been given to the Septaria, from a supposed resemblance of the surface, when polished, to the back shell of a turtle. The dark rich colour of the spar results from the presence of iron. Notwithstanding the irregular veining, so that no two are alike, there is a general pattern which they appear to follow. Thus, in the larger and spherical stones, the centre is filled with spar, from which it radiates towards the edge or outside, in a number of points not unlike those marked on a mariner's compass, each apex or point being about equally distant from the centre. Microscopic examination has detected the laminæ of the hardened clay to be parallel to the laminæ of the shale or marl in which the stones are enclosed. In some, where the crystallisation is incomplete, and a space remains, water is found, which either originated with the formation, or has been drawn by capillary attraction into minute fissures from the exterior.

Sir H. De la Beche,* referring to their formation, supposes that, during the deposition of the stratum in which they occur, the particles of carbonate of lime separated themselves from the muddy mass in which they were held in suspension, and accumulated at different points at or about at the same level. This gathering together of similar matter, distributed through a soft mass, is seen in the formation of crystals of selenite, in iron pyrites, flints, and other nodules. In the case of septaria, he supposes that after the segregation had taken place, and while the nodules were in the course of consolidation, a contraction of the interior took place, the cracks not extending to the outer surfaces, so that the largest openings were central. In such cases the cracks would become filled and would form veins, the contents of which would vary according to the nature of the deposit of which the concretions formed a part. On the north shore of Weymouth small hard nodules, known as "kidney-stones," formed of reddish-brown clay with veins of spar, not unlike the septaria, are washed out of the cliff. A singular septaria-stone was recently found in the Oxford Clay of Radipole:

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* 'Geological Observer,' p. 597.

The trunk of a fossil tree, 3 feet in length, 6 inches in diameter, from the centre of which the spar radiates to the exterior of the trunk, which is surrounded by similar spar. From this outer coating there are other radiating septa passing into the indurated clay or matrix, forming, when cut, a circular section of Septaria having the fossil trunk for its centre. Other nodules of small dimensions are sufficiently numerous in the Oxford Clay at Boulogne to be used for making a superior description of Roman cement.*

WEYMOUTH HARBOUR.

South of the Greenhill this formation does not come to the surface, but it may be seen at low water on the shore of the Harbour of which it forms the bed. Between this and the Greenhill, it is reached through beds of shingle, and sand when the excavations are carried to a sufficient depth to pierce through the former deposits; hence the Oxford Clay is the water-bearing bed of the town, or that which yields water in wells.†

In deepening the Harbour, the following fossils are met with :—

Ammonites cordatus.
„ *vertebralis.*
„ *sublævis.*
„ *Kœnigi.*
„ *athletus.*
Belemnites Owenii.
„ *hastatus.*
„ *gracilis.*
Myacites oblata.

Modiola bipartita.
„ *cuneata.*
„ ?
Nucula ornata.
Perna mytiloides.
Thracia pinguis.
„ *recurva.*
Exogyra.

---

* For every 100 parts these nodules contain—

Carbonic acid	36
Lime	34·50
Silica	15
Iron	7
Alumina	4·75
* * * *	2·75

From a MS. in the Museum of the Town College of Boulogne.

The Jurassic rocks of the Boulonnais have been studied of late years by Hebert, Pellat, Rigaux, Barrois, and others.

† The fine water with which Weymouth is supplied has its source in the Chalk Marl at Preston.

FOSSILS OF THE OXFORD CLAY, WEYMOUTH.

Fig. 14

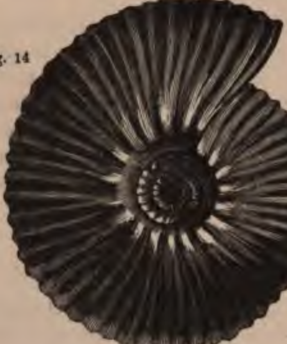

Fig 15

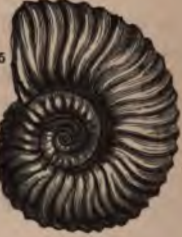

Fig. 16

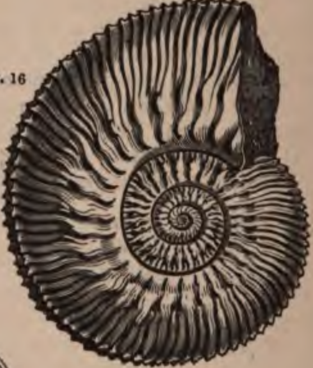

Fig. 17

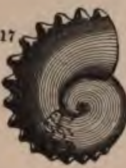

Fig. 21

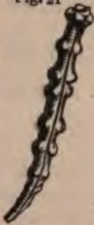

Fig. 18

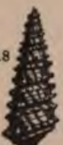

Fig. 20

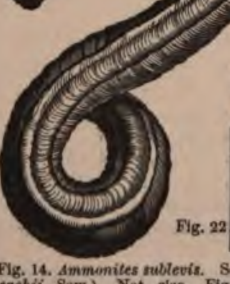

Fig. 19

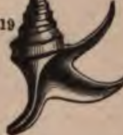

Fig. 22

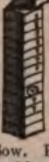

Fig. 23

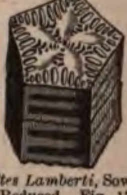

Fig. 14. *Ammonites sublevis.* Sow. Reduced. Fig. 15. *Ammonites Lamberti*, Sow. (*Leachii*, Sow.). Nat. size. Fig. 16. *Ammonites Jason.* Rein. Reduced. Fig. 17. *Ammonites crenatus.* Brug. Nat. size. Fig. 18. *Cerithium Damonis.* Lycett. Nat. size. Fig. 19. *Alaria trifida.* Phil. Nat. size. Fig. 20. *Vermilia sulcata.* Sow. Nat. size. Fig. 21. *Serpula vertebralis.* Sow. Nat. size. Fig. 22. *Pentacrinus*, stem. Nat. size. Fig. 23. *Pentacrinus*, magnified.

HAM CLIFF (NORTH SHORE).

Here the fossils are numerous, though generally compressed, and difficult of identification. The formation is traversed by lines of separation (joints) about one foot apart, inclined at an angle of 45°, and running transversely to the plane of stratification.*

JORDAN CLIFF.†

A valley of denudation has been formed through the Coral Rag, and Oxford Clay between Preston Hill and Jordan Cliff, where a beautiful stream runs into the sea from the same source as supplies Weymouth.

The clay beds are here interspersed with thin stony layers. There is also a singular bed of Serpulæ (*Vermilia sulcata*) some two or three inches in thickness, implying the former existence of an undisturbed sea bottom.

Gryphœa dilatata and Septarian nodules are abundant.

The upper part of the cliff contains numerous impressions of large Ammonites, Modiolæ, &c.

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* For list of fossils from this locality, see following pages.

† At Jordan Hill, the site of the Roman Station "Clavino," extensive remains of a Temple were discovered in the year 1843, the walls of which enclosed an area of 110 square feet.

Roman coins, weapons, pottery, and a great quantity of bones and horns of young Bulls were found; also beds of ashes alternating with tiers of tiles, each pair of which enclosed the skeleton of a Bird with one copper coin. This alternation was repeated sixteen times between the top and bottom tier. The Birds were referred to the Raven, Crow, Buzzard, and Starling. It is thought that the building must have been a Temple of Esculapius, which received the votive offerings of Roman invalids who visited this coast for purposes of health. Dr. Buckland was present at the above opening, and I remember when, on a Roman silver coin being found, he exclaimed with his characteristic humour, "The very fee, I declare, that was offered to Esculapius."

For a fuller account of the opening, see 'Proc. of Ashmolean Soc.,' Oxford, 1844.

It has been proposed again to uncover and enclose the site which is attached to the Lulworth estate.

GREENHILL.

Here the Oxford Clay passes into a brownish colour, characteristic of the upper part of this formation. *Septaria* in layers and much flattened are numerous, as also Selenite in crystals with lignite.

The following fossils are here met with :—

Vertebræ of *Ichthyosauri* and *Plesiosauri*, Teeth, and Scales of *Lepidotus*.

Ammonites athletus (large).
   " *cordatus.*
   " *cymodoce.*
   " *Gowerianus.*
   " *Kœnigi.*
   " *Reginaldi.*
   " *vertebralis.*
Belemnites Owenii.
   " *hastatus.*
   " *gracilis* (numerous).

Cerithium Damonis.
Gryphœa dilatata.
Exogyra virgula.
Nucula ornata.
Serpula vertebralis.
Vermilia sulcata.
Pentacrinus Fisheri, Forbes. The last-named fossil is found at the base of the cliff, now concealed by shingle. This species has not been recorded in any other locality.

RADIPOLE BACKWATER.

Half a mile west from the Greenhill, and near to that part of the Backwater marked in local maps "Radipole Barracks,"* the Oxford Clay is cut through by the Great Western Railway, and after an embankment of a quarter of a mile, a second opening occurs. Fossils are numerous in the first cutting, but much compressed.

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* The Barracks referred to were removed many years since.

The beds are bituminous, and have the peculiar odour which characterises the inflammable shale of the Kimeridge Clay, though of a less pungent nature. A great variety of fossils have been collected from this spot, but the slopes having since been turfed over, the section is no longer exposed. The best Oxford Clay fossils of the district, and those in the greatest variety, have been procured from the bed of the Backwater. The stratum referred to rises to about 2 feet from the surface, in a direction from E. to W., and is crossed by the railway embankment. The bed in question dips rapidly to the South. It is here that the best Septaria are found.

On the west shore of the backwater, several species of small mineralised Ammonites are to be found, together with *Gryphæa dilatata*, *Belemnites gracilis*, Lignite, and crystals of selenite; and the same fossils reappear in a similar manner in the low cliff of the Fleet, forming the western termination of the Oxford Clay in this district, and indeed in Great Britain.

LIST of FOSSILS found in the Oxford Clay at Radipole and at Ham Cliff, North Shore:—

REPTILIA.

Ichthyosaurus. Vertebræ and other bones.
Plesiosaurus. Ditto.

CEPHALOPODA.

Ammonites annularis, Rein.
  „ *athletus*, Phil.
  „ *cordatus*, Sow.
  „ *crenatus*, Brug.
  „ *Chauvinii*, D'Orb.
  „ *cymodoce*, D'Orb.
  „ *Duncani*, Sow.
  „   var. *spinosus*, Sow.
  „   „ *gemmatus*, Phil.
  „ *Gulielmi*, Sow.
  „ *Gowerianus*, Sow.
  „ *flexicostatus*, Phil.
  „ *hecticus*, Rein.

Ammonites Jason, Rein.
  „ *Kœnigi*, Sow.
  „ *Lamberti* (*Leachii-Mariæ*), Sow.
  „ *lenticularis*, Phil.
  „ *longispinus*, Sow.
  „ *modiolaris* (*sublævis*), Sow.
  „ *macrocephalus*, Schloth.
  „ *perarmatus*, Sow.
  „ *placenta*, Leckenby.
  „ *Reginaldi*, Morris.
  „ *striolaris*, Quenst.
  „ *vertumnus*, Leck.
  „ *Williamsoni*, Phil.
Nautilus hexagonus, Sow.
Belemnites gracilis, Phil.
  „ *hastatus*, Blain.
  „ *Owenii*, Pratt.
  „ A very large species.

GASTEROPODA.

Alaria trifida, Phil.
Cerithium Damonis, Lycett.
Pleurotomaria. Not distinguishable from *P. reticulata.*
Patella.

BRACHIOPODA.

Lingula ovalis, Sow.
Rhynchonella Thurmanni, Volt.
  „ *varians*, Schloth.
Terebratula intermedia, Sow.

CONCHIFERA.

Avicula inæquivalvis, Sow.
  „ Sp.
Arca Quenstedtii, Lyc.
Astarte carinata, Phil.
  „ *zonata*, Roemer.
Cucullæa concinna, Phil.
Cardium striatulum, Sow.

Gryphœa. Sp.
Gresslya peregrina, Phil.
Hinnites velatus, Goldf.
Modiola bipartita, Sow.
„ *cuneata,* Sow.
Mytilus.
Myacites recurva, Phil.
„ *oblata,* Sow.
Nucula ornata, Quens.
Ostrea flabelloides, Lam.
„ (?)
Perna mytiloides, Lam.
Pinna lanceolata, Sow.
Pholadomya paucicostata, Ag.
„ *angustata,* Sow.
Pecten demissus, Phil.
„ *fibrosus,* Sow.
„ *annulatus,* Sow.
„ *vagans,* Sow.
Pholas compressa, Sow.
Trigonia irregularis, Seebach (in pure clay).
„ *elongata,* Sow. (in gritty clay).
Thracia pinguis, Ag.
„ *depressa,* Sow.
Venus. Small sp.

ARTICULATA.

Crustacean remains.
Serpula vertebralis, Sow.
Vermilia sulcata. Sow.

ECHINODERMATA.

Ophioderma Weymouthiensis. N. sp.
Pentacrinus. Columns of a large species.*

Lignite and Vegetable Impressions.
Numerous Septaria.
Crystals of Selenite.

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* The detached portions of these columns are known as "St. Cuthbert's beads," and, from having been found in the neighbouring tumuli, they are supposed to have been worn as ornaments by the ancient Britons.

For figures of most of the above species, see Supplement, Plates 1, 2, 3, 17, 18.

The entire absence of Fish-remains in the Oxford Clay is worthy of note; these are numerous in the Kimeridge Clay.

CORALLIAN (CORAL RAG—CORALLINE OOLITE).

For figures of Fossils, see Supplement, Plates 4, 5, 6, 17.

This formation is composed of alternating beds of coarse limestone, calcareous sands, occasional clay-partings, and large concretionary masses of grit. The upper and lower portions, between which the coralline (or, as is the case here, the shelly) bed intervenes, are known as the Upper and Lower Calcareous Grits. The entire thicknesss of the series at Weymouth is 250 feet.* At Linton Hill, near Abbotsbury, the Corallian rocks attain their greatest elevation.

Professor Sedgwick ('Annals of Philosophy' for the year 1826) published the following list of the successive beds of this formation occurring between Weymouth Harbour and the foot of Sandsfoot Castle: †

No. 1. Beds near the Jetty, on Oxford Clay, composed of a calcareous grit, harsh and meagre to the touch, with irregular stems branching out and intersecting each other in every direction.

No. 2. Thin beds of yellow sands and sandstone.

No. 3. Strong beds of calcareous grit like No. 1, but more ferruginous.

No. 4. Blue argillaceous beds alternating with hard compact beds.

No. 5. Beds of yellow sand resembling No. 2; near the tops of calcareous grit with argillaceous partings in structure as Nos. 1 and 3.

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* The corresponding strata on the coast of Yorkshire are 200 feet thick and thus divided:—

Upper calcareous grit	60 feet.
Coral rag, or middle portion	60 „
Lower calcareous grit	80 „
	200 feet.

Phillips' 'Quart. Journ. Geol. Soc.,' vol. xiv. p. 84.

† These beds have been further subdivided in the Memoir 'On the Geology of Weymouth,' by Prof. Buckland and Sir H. De la Beche.

No. 6. Beds of oolite with argillaceous partings alternating with other shelly oolitic beds, like Forest Marble.

No. 7. Thin beds of oolitic marble with *Echinobrissus* (Nucleolites) *clunicularis.*

No. 8. A group of impure sandy oolite with *Ostrea deltoidea* and other fossils.

No. 9. Sandy oolite with innumerable *Trigonia clavellata.*

No. 10. Kimeridge Clay, with large beds of *Ostrea deltoidea.*

No. 11. Beds of ferruginous calcareous grit alternating with beds of red and green sand and blue clay with *Ostrea deltoidea.*

A line drawn from each end of the above section in a south-west direction, terminating at the Fleet backwater, forms the southern zone of the Corallian; while from the coast at Osmington another but narrower belt extends to Abbotsbury on the west.

The *Lower Calcareous Grit* commences at the base of the Nothe Cliff, where the passage from the Oxford Clay is sharp and well-defined. The *Upper Calcareous Grit* graduates into the Kimeridge Clay on the coast near Sandsfoot Castle: between the Upper and Lower Calcareous Grits the beds become more oolitic, and organic remains more numerous and better preserved.

This portion of the series has given rise to the name of the formation, owing to the large number of *corals* by which in some districts it is characterised. In Weymouth the Coral Rag yields but few corals. It is often found that mollusca are rare where corals are numerous, and *vice versâ.*

Messrs. Blake and Hudleston * have divided the Corallian Rocks of England into five separate areas, viz. —

1. Weymouth District.
2. North Dorset.
3. North Wilts and Oxfordshire range.
4. Cambridge reef.
5. Yorkshire basin.

In correlating these various deposits, they consider the series when complete to be thus represented in ascending order:—

1. Lower Calcareous Grit.
2. Lower Limestone or Hambleton Oolite.
3. Middle Calcareous Grit.
4. Coralline Oolite.
5. Coral Rag.
6. Supra-Coralline Beds.

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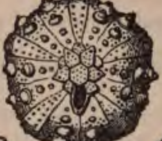
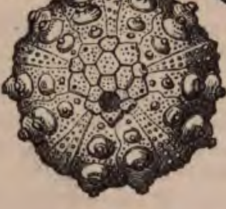
* "On the Corallian Rocks of England," by Rev. J. F. Blake and W. H. Hudleston. 'Quart. Journ. Geol. Soc.,' vol. xxxiii. 1877. See also Waagen "On Jurassic Classification." 'Quart. Journ. Geol. Soc.,' vol. xxi. 1865.

Fig. 24.





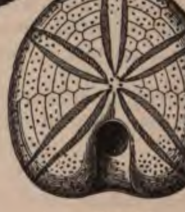


Fig. 25.

Fig. 26.

24. *Acrosalenia decorata.*
25. *Hemicidaris intermedia.* The Calne Cidaris.
26. *Echinobrissus (Nucleolites) scutatus.*
All natural size. Coral Rag, Weymouth.

The *Echinidæ*, though numerous throughout the Corallian rocks, are almost absent in the Kimeridge Clay beds immediately above; the only exception being that in the lower bed of the Kimeridge Clay, *Cidaris florigemma* is fairly abundant (spines). The paucity of Echinidæ in the Kimeridge series may arise from the clayey strata being less favourable to their preservation than are the calcareous and stony beds, or from water containing clayey matter having been unsuitable to their mode of life. They are not abundant either in the Oxford Clay or Kimeridge Clay, though more or less plentiful in the beds adjacent to these formations.

LIST OF FOSSILS FROM THE CALCAREOUS GRIT AT NOTHE POINT AND CLIFFS WESTWARD.

REPTILIA.

Teleosaurus.

CEPHALOPODA.

Ammonites lenticularis. Phil.
„ *cordatus.* Sow.
Belemnites hastatus. Blain.
Nautilus hexagonus. Sow.

GASTEROPODA.

Pleurotomaria Munsteri, Sow.
Chemnitzia Heddingtonensis, Sow.
Cerithium muricatum, Sow.

CONCHIFERA.

Avicula ovalis, Phil.
Anomia radiata, Phil.
Cyprina tancrediformis, Bl. and H.
Exogyra spiralis, Goldf.
Gryphæa dilatata, Sow.
Goniomya literata, Sow.
Myacites decurtatus, Phil.
Opis Phillipsi.
Ostrea solitaria, Sow.
  „ *gregaria*, Sow.
Perna quadrata, Sow.
  „ N. sp.
Pholadomya æqualis, Sow.
  „ *concinna*, Ag.
Pecten vagans, Sow.
  „ *fibrosus*, Sow.
  „ *demissus*, Phil.
Trigonia, clavellated sp.

ARTICULATA.

Vermilia sulcata, Sow.
Serpula tricarinata, Sow.

CRINOIDEA.

Millericrinus echinatus, Phil.

The *Nothe Clay* at the base of the fort, where it offered great difficulties in securing a foundation for the sea-wall, though resembling the Oxford Clay, must be regarded as subordinate to the Corallian, rather than Oxfordian.

It contains but few fossils, and of the latter rather than the former type:—Small *crustacea*, of undescribed species, large *Gryphæa* (not dilatata) *Modiola Lonsdalei* and a clavellated Trigonia, apparently undescribed, not being figured by J. C. Mansel-Pleydell in his memoir 'On the Dorset Trigoniæ,' or in the larger work on the 'British Fossil Trigoniæ,' by Dr. Lycett. I have provisionally named it *Trigonia Medlycotti.*

Description: Length, 2⅝ inches; greatest width, 1⅝ inch; ditto of area, 1 inch. Extremity sharp, but not attenuated. Escutcheon and area nearly straight. Tubercles, of which there are from 10 to 12 in a slightly-curved row, are closer set than in "*T. irregularis.*"

BINCLIFF GRIT SERIES.

Proceeding westward, the Upper Grit Series reach their greatest elevation at "Bincliff" where the harder beds pass into "foxy sands" containing large indurated masses ("Doggers") of hard standstone. The upper portions contain a few ill-preserved fossils of species common to the "Upper and Lower Calcareous Grit." These beds in part reappear in the cutting of the Weymouth and Portland Railway at Rodwell, where the following series has been determined:—

SECTION OF CORALLIAN BEDS IN RODWELL CUTTING.

		ft.	in.
Trigonia Beds.	1. Blue Clay.		
	2. Hard, blue, impure limestone in six courses, with numerous casts of *Trigoniæ*, *Pleurotomariæ*, &c.	12	0
	3. Rubbly Limestones with marly partings (8 in.), very slightly oolitic	7	0
	4. Oolite Marl, full of fossils, particularly *Myacites*. This might also be termed a fine-grained pisolite	4	0
	5. Grey, rubbly Limestone, scarcely oolitic	1	6
	6. Stiff Marl, very oolitic towards the base, with a hardened ferruginous bed in the centre	4	9
	7. Hard, ferruginous Oolite	4	0
Osmington Oolite Series.	8. Marl with flaggy calcareous grit	3	0
	9. Strong, semi-oolitic Flagstone with calcareous markings	1	0
	10. Blue Clay with oolite grains at the base	3	8
	11. Solid, shelly and oolitic light-coloured limestone with *Echinobrissus scutatus*	3	8
	12. Light-coloured Marl, becoming oolitic below ..	2	0
	13. Rough, shaly Oolite in two blocks	4	0
Bincliff Grits.	14. Marls	6	0
	15. Fine-grained Calcareous Grit	2	0

Returning to the coast: West of Bincliff are marly and limestone beds corresponding to the Osmington Oolite, but which are better displayed on the coast near Osmington Mills. About midway between Bincliff and Sandsfoot Castle is the "Trigonia-bed" of the Coral Rag, which well deserves its name, the ledge or apron of the shore being as it were paved with examples of *Trigonia clavellata.*

CORAL RAG (PROPER).

Immediately above, in a low cliff, is a bed remarkable for the number of its fossils, though so firmly united to their matrix that their extraction is somewhat difficult. This and the corresponding bed near Osmington Mills have furnished the greatest number of Coralline fossils found in the Weymouth district, and as it contains here as elsewhere several species of corals, its original name deserves to be retained.*

Instead of furnishing separate lists of fossils that are found in these two localities, I have followed Messrs. Blake and Hudleston, in giving a list embracing both, adding other species which have come under my notice.

LIST of FOSSILS found in the Coral Rag at Sandsfoot and Osmington:—

PISCES.

Asteracanthus. (Dorsal Spine.)
Gyrodus Cuvieri. Ag. (Palatal Teeth.)

CEPHALOPODA.

Ammonites cordatus, Sow.
„ *perarmatus*, Sow.
„ *eupalus*, D'Orb.
„ *lenticularis*, Phil.
Nautilus hexagonus, Sow.
Belemnites abbreviatus, Miller.
„ *var.*

GASTEROPODA.

Alaria composita, Sow.
„ *Deshayesii*, Buv.
„ *hamulus*, Desl.
„ *seminuda*, Desl.
Chemnitzia Heddingtonensis, Sow.
„ *Rupellensis*, D'Orb.
Cerithium muricatum, Sow.

---

* At Steeple Ashton, in Wiltshire, and Nattheim, in Wurtemberg, they occur in the greatest profusion. *Thecosmilia annularis*, found in the Coral Rag of Weymouth, is the common species at Steeple Ashton.

Cylindrites elongata, Phil.
Dentalium cinctum, Goldf.
Littorina pulcherrima, Dolf.
Nerinœa Goodhallii,* Sow.
　„ *fasciata*, Voltz.
　„ *Desvoidyi*, D'Orb.
Nerita minuta, Sow.
Natica corallina, Damon.
　„ *clytia*, D'Orb.
　„ *Clio*, D'Orb.
　„ *silicea*, Quens.
Phasianella striata, Sow.
Pleurotomaria reticulata, Sow.
　„ Allied to *Anglica*, Sow.
　„ *Münsteri*, Roem.
Turritella Jurassica, Quenst.

CONCHIFERA.

Astarte aliena, Phil.
　„ *extensa*, Phil.
　„ *modiolaris*, var., Lam.
　„ *ovata*, Sow.
　„ *polymorpha*, Cont.
　„ *Thompsonii*, Damon.
Arcomya. Sp.
Ceromya excentrica, Ag.
Cypricardia glabra, Bl. and H.
Cardium cyreniforme, Buv.
Isodonta Deshayesii, Buv.
Myacites decurtatus, Phil.
　„ *Jurassi*, Brong.
Nucula nuda, Phil.
Opis Phillipsi, Mor.
　„ *corallina*, Damon.
Pholadomya decemcostata, Roem.
　„ *paucicostata*, var., Roem.
　„ *œqualis*, Sow.
Protocardium isocardioides, Bl. and H.

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* A singular spiral shell which, when entire, exceeds a foot in length. Figure in Supp., Pl. 5, Fig. 8.

Trigonia clavellata, Sow. (Remarkably abundant in single valves.)
  „ *Meriani*, Ag.
  „ *monilifera*, Ag.
Dr. Lycett excludes *T. Bronnii*, Ag. as a form of *T. clavellata*.
Unicardium sulcatum, Leck.
Sowerbia triangularis, Phil.
Cucullœa corallina, Damon.
Mytilus pectinatus, Sow.
Modiola subœquiplicata, Goldf.
Pinna granulata, Sow.
Avicula Struckmanni, De Lor.
  „ *pteropernoides*, Bl. and H.
Perna quadrata, Phil.
  „ undescribed.
Goniomya (Mya) literata, Sow.
  „ v. *scripta*, Sow.
Isocardia minima, Sow.
  „ *inflata*.
Inoceramus (?)
Gervillia aviculoides, Sow.
Lima elliptica, Whiteaves.
  „ *rigida*, Sow.
  „ *pectiniformis*, Schloth.
Plicatula fistulosa, M. and L.
  „ *semiarmata*, Et.
  „ *tubifera*, Lam.
Pecten arcuatus, Sow.
  „ *annulatus*, Sow.
  „ *demissus*, Phil.

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* Of fossil Trigoniæ 112 species are recorded by Dr. Lycett from the secondary rocks of Great Britain. 'British Fossil Trigoniæ,' Palæontographical Soc., vol. for 1872.

Twenty-nine species are referred to Dorsetshire. 'Proc. Dorset Nat. Hist. and Field Club,' vol. iii. 'On the Dorset Trigoniæ,' by J. C. Mansel-Pleydell.

This genus has not yet been discovered in Tertiary strata. *Trigonia pectinata*, a beautiful shell with pearly interior of rich variegated colour, is not uncommon near Swan River, N. S. Wales, the only sea in which it has yet been found in a living state.

Pecten fibrosus (var.), Sow.
  „ *intertextus*, Roem.
  „ *qualicosta*, Et.
  „ *virdunensis*, Buv.
  „ *vimineus*, Sow.
Hinnites velatus, Goldf.
Ostrea deltoidea, Sow.
  „ *duriuscula*, Ph.
  „ *gregaria*, Sow.
  „ *Rœmeri*, Quenst.
  „ *solitaria*, Sow.
  „ (*Exogyra*) *nana*, Sow.

ECHINODERMATA.

Astrogonium (?)
Acrosalenia decorata, Forbes.
Cidaris florigemma, Phil.
Diadema (?)
Echinobrissus (*Nucleolites*) *scutatus*, Lam.
Hemicidaris intermedia, Flem.
Pseudodiadema versipora, Ph.
Ophiurella nereida, Wright.

ANNELIDA.

Serpula intestinalis, Phil.
Vermilia sulcata, Sow.

CORALS.

Thamnastrea arachnoides, E. and H.
  „ *concinna*, Phil.
Thecosmilia annularis, Flem.
Alcyonium.

Crustacea.

In the upper beds of the Corallian rocks west of Sandsfoot Castle, Mr. E. T. Newton discovered a Crocodilian Jaw.*

The singular appearance of masses of grit, on the shore near the Old Castle, will doubtless attract attention. Their surfaces are traversed with vegetable remains spreading in all directions, forming a kind of network, a condition which arises from the casts themselves, and the grit over which they spread, having decayed unequally.

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* Quart. Journ. Geol. Soc.,' vol. xxxiv. p. 398, 1878.

CLIFFS (SOUTH OF WYKE CHURCH).

The "Coralline," or "Osmington Oolite," is a cream-coloured rock, the grains of which are larger than any others of the Corallian, and more uniform in texture, but from the manner in which it "weathers" it is ill adapted for building purposes.* When the cliffs are laid bare, fossils of the undermentioned species are tolerably abundant:—

Nerinæa Bernardiana, D'Orb.
Chemnitzia Heddingtonensis.
Natica.

Cucullæa corallina.
Trigonia clavellata.
Myacites decurtatus.
Pecten vagans.
Ostrea. Small sp.

Echinobrissus (*Nucleolites*) *scutatus.* (Numerous.)

In a quarry, some 100 yards from the stream, *Alcyonium* in an upright position is plentiful, though it is bare of other fossils.

CALCAREOUS GRIT (PRESTON HILL TO HAM CLIFF; NORTH SHORE).

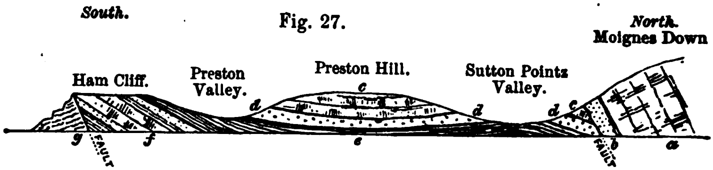
In this very fine section the Calcareous Grit series is well shown. The immense blocks detached from the overlying cliffs are by reason of the sandy partings, as on the Weymouth side, covered with fucoidal remains, some with a furrowed, and rippled surface, formed by the tidal waters before the stone was consolidated, and answering to the ripple-marks and other conditions of an existing sandy shore. Numerous cracks that traverse the stony beds have their sides coated with a white stalagmitic deposit of carbonate of lime.

At *Ham Cliff* the Coral Rag is let down, by a conspicuous fault, to a level with the Oxford Clay, as seen in the section Fig. 27. At Preston Hill the beds are horizontal, but here they have a considerable dip.

---

* Referring to this formation, Mr. Conybeare observes that Oxford has reason to regret its vicinity to this rock, for it has been used in many of the public structures there, and after a few years' exposure it scaled off in large flanks.

Fig. 27.



a. Chalk. *b.* Upper Greensand. *e.* Portland Stone. *d.* Portland Sand.
e. Kimeridge Clay. *f.* Coral Rag. *g.* Oxford Clay.

FOSSILS FROM THE CALCAREOUS GRIT (PRESTON AND JORDAN CLIFFS).

Ammonites perarmatus.
„ *Achilles.*
„ *discus.*
Pleurotomaria reticulata.
Chemnitzia Heddingtonensis.

Trigonia clavellata.
Pholadomya paucicostata.
Modiola (?)
Myacites decurtatus. (Large.)
Gryphœa dilatata. (Large.)
Pecten vagans.
„ (?)
Ostrea solitaria.
Crypts of *Modiola* in *Gryphœa dilatata.*

Serpula.

Lignite.

Several of the above species, which are common to this and to the adjacent beds, here attain their maximum size. Ex. *Trigonia clavellata, Pholadomya paucicostata, Myacites decurtatus, Gryphœa dilatata,* all of which are larger than the same species found in the Oxford Clay, or Coral Rag (middle bed).

Towards the top of the cliff over Radcliff Head a portion of the Calcareous Grit, highly oolitic, has disintegrated and formed a loose deposit like so much mustard-seed. On examining these particles under a strong magnifying glass, it will be observed that a great part of them consist of organised bodies belonging to the order Foraminifera.*

CORAL RAG FROM THE SHORE AT OSMINGTON MILLS TO HAM CLIFF.

The Kimeridge Clay, which rises from the shore a little west of Osmington Mills, is underlain by—

1. Grey-coloured marly stone (Upper Calcareous Grit), non-oolitic, much broken in a vertical direction, and interspersed with clay-partings of like colour. The stony beds contain numerous casts of *Pleurotomaria*, *Myacites*, *Pholadomya*, and other species common to the Coral Rag.
2. Coarse ferruginous Grit (containing *O. deltoidea*): that towards the middle portion is oolitic, the grains being iron-red, and imparting a peculiar tinge to the fossils of this stratum. It is rich in organic remains, generally well preserved. By way of distinction I have denominated this the "red bed" of the Coral Rag.
3. Shelly bed of bluish-grey Ragstone, very fossiliferous, highly charged with *Trigonia clavellata*, and corresponding to the stratum already described in the lower cliff, a quarter of a mile north of the Sandsfoot Castle.
4. Pea-grit. An aggregation of calcareo-silicious rounded particles of irregular shape, mingled with oolitic grains, firmly held by a cementing matrix, of a bluish colour, without fossils. I have not observed this bed in any other locality.
5. Light-coloured Clay, destitute of fossils.
6. Cream-coloured rock, Osmington Oolite, which at the village of Osmington, close by, is quarried for building. It agrees with the bed forming the cliff at the back of Wyke Church, having its characteristic fossil, *Echinobrissus* (*Nucleolites*) *scutatus*, in abundance.

On the shore, a little further to the west, where this stratum rises to the surface tilted inland, the under sides of some of the blocks are strewed with well-preserved fossil shells, with *Echinidæ*, *Annelids*, and *fucoidal* impressions.

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* Foraminifera have a great vertical range. Sir R. L. Murchison states that the same species have been traced from the Coal-measures through the succeeding strata to the present time. It is easy to understand how such minute bodies might survive change which would prove destructive to larger animals.

List of the Fossils that may be observed in the position referred to. Several are not found in any of the adjacent beds, and some appear to be undescribed species:—

Echinobrissus (*Nucleolites*) *scutatus.*
Nerinœa.
Alaria.
Cerithium.
Buccinum.
Natica, two species.
Trochus.
Opis.
Cucullœa, or Arca.
Modiola.
Trigonia clavellata.
Ostrea.
Gryphœa.
Myacites.
Lima.
Pecten.

7. Grey-coloured Grit with Clay-partings, agreeing with bed No. 1, followed by the Oxford Clay.

The strata, throughout this locality, are very much tilted at different angles, and are fractured so as to have produced several faults, which are marked by deep indentations in the cliff. Some of the beds dip beneath the surface and at a short distance reappear with a different degree of inclination.

Corallian.—East of Osmington Mills.

Most of the beds just enumerated are repeated on the coast east of Osmington Mills, where the upper part of the series passes into the Kimeridge Clay at Ringstead Bay. See Fig. 33 for the order of succession.

A cascade passes over a bed of ferruginous grit, which is here of considerable thickness, and more homogeneous in texture than in the last-named locality. Among the prevailing fossils are a large species of *Nucleolites*, casts of *Trigonia*, *Pholadomya*, &c. It is also much perforated with borings of Mollusca.

Corallian.—Broadwey.

In a quarry near and south of Broadwey House, the residence of John Moor Bridge, Esq., stony beds, each about 2 feet in thickness and highly fossiliferous, alternate with stiff brown-coloured clays. The following fossils were collected here.

The quarry is now closed, but the list will probably apply to any fresh opening near at hand.

Chemnitzia Heddingtonensis.
Nerinœa (?)
Nerita hemispherica, Roemer.
Natica, two species.
Pleurotomaria reticulata.

Ceromya excentrica (*Isocardia excentrica*), Voltz.
Pecten vagans, and two other species.
Ostrea deltoidea.
  „ *duriuscula.*
  „ *solitaria.*
  „ (?)
Trigonia clavellata.
  „ *monilifera.*
Myacites, two species.
Opis corallina.
Gervillia aviculoides.
Cucullœa corallina.
Pholadomya œqualis.
Isocardia minima.

Terebratula insignis, Quenst.

Echinobrissus (*Nucleolites*) *scutatus.*

CORALLIAN—ABBOTSBURY.

At this village,* the extreme west of the Corallian, many of the equivalent beds already described are present, though under somewhat different conditions. The irregular outline and deep colour of its rocks give a distinctive character to the landscape. The upper part of the formation contains certain oolitic grains of iron-ore in such quantity as to form a rich ore of hydrous oxide of iron (Limonite), of which the following is an analysis, made by Prof. G. D. Liveing, of St. John's College, Cambridge, from a portion taken at random from a road-cutting between the village and the Earl of Ilchester's house:—

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* In the "Fleet" Stream at Abbotsbury is a Decoy Pond and Swanery attached to the Ilchester Estate, the Castle and beautiful gardens of which are situated a little out of the village. Besides these attractions, there is an ancient Chapel, dedicated to St. Catherine, also the remains of a Benedictine Monastery, founded here in 1004. Hence this interesting spot is much frequented during the summer months.

Sesqui-oxide of Iron	43·97	per cent.
Silica	42·60	„
Magnesia	1·40	„
Lime	trace	
Common Salt	„	
Water	11·8	„
Total	99·85	„

The large amount of Silica (nearly one-half the bulk) lessens its commercial value. The iron-ore (Hematite) of the Carboniferous Series contains, when pure: iron 70, oxygen 30 per cent.

Messrs. Blake and Hudleston say that a sample of the oolitic granules of the Abbotsbury ore yielded the following:—

Moisture	1·21	per cent.
Water	11·29	„
Ferric Oxide	73·57	„
Alumina and soluble Silica	4·17	„
Lime	1·60	„
Magnesia	1·41	„
Insoluble in HCl	5·53	„
Organic matter, carbonic acid, and loss	1·22	„
Phosphoric Acid	trace	
Total	100·00	

The results ot Analysis No. 1 is equal to 34 to 35 per cent. of iron in the roasted ore. At Red Lane, a little out of the village, the formation is of a deep rusty-red colour, forming incoherent and heavy matter; while towards Gorwell, half a mile to the west, there are hard silicious bands containing a larger proportion of metallic iron. In the former state it exists to a considerable extent; in the latter it is abundant.

Extracts from a report made by Mr. Bristow, 1st August, 1849, in reference to an iron-ore in the immediate neighbourhood of Abbotsbury:—

"The upper beds of the Coral Rag in the locality in question consist ot sand cementing together oolitic grains of hydrous oxide of iron, in such quantities as to form a rich ore, pronounced by Professor Playfair to contain 45·9 (say 46) per cent. of metallic iron . . . . taken from a road-cutting between the village and the Earl of Ilchester's house, at which spot it is less rich than on the north side of Abbotsbury.

"The general inclination of the Coral Rag (and of the subordinate strata), of which the iron-bearing beds constitute the upper portions, is towards the north, at an angle varying from 10° to 15°; but a fault north of the village has the effect of reversing the dip, and of producing an inclination to a similar amount in the opposite direction. The slope of the ground varying little from the dip of the strata, the last are for the most part at or near the surface, and consequently easily accessible; but in the valley at the western end of Abbotsbury, the beds containing the iron ore are concealed by an oval patch of Kimeridge Clay, about half a mile in length, from beneath which they emerge to form the high grounds in the neighbourhood around. At the eastern end of the village, and on the north side of Linton Hill, these upper strata of Coral Rag also dip under, and are overlaid by, Kimeridge Clay.

"I have not yet measured the thickness of the iron-beds, but they cannot be less than 30 or 40 feet."

Other beds of the Coral Rag in the neighbourhood of Weymouth are more or less ferruginous, as may be seen in the rusty-looking cliff near Sandsfoot, but nowhere is it so rich in iron as at Abbotsbury. At some period these beds will doubtless be turned to account, either by the erection of furnaces on the spot, or, what is more probable, by the conveyance of the raw material to existing foundries elsewhere. The promoters of the railway now in progress, from Abbotsbury to the Great Western station at Upwey, consider this will be one of their principal sources of revenue.*

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* Former Earls of Ilchester were aware of the value of this formation at Abbotsbury, some of whom rather regretted its existence than otherwise, fearing it might give encouragement to projects that would destroy the natural scenery and wild solitude of this part of their estate, which was always a favourite residence.

The Oolites of Yorkshire, Wilts, and other parts of England contain similar deposits. At Westbury, in the latter county, blast-furnaces for smelting the Oolitic ore have long been in operation. Throughout France the foundries are largely supplied with an Oolitic ore. That near Boulogne employs 4000 men. In Belgium, as is visible in passing over the Railway from Charleroi to Namur, blast-furnaces extend for several miles, which are almost entirely fed with Oolitic ore. For a general description of the Oolitic ironstones of France, see a paper by Prof. G. A. Lebour; Trans. N. of Eng. Inst. Eng., vol. xxv. p. 59.

Section of the Iron-bearing beds at Red Lane,* Abbotsbury :—

	Ft.	In.
1. Loose ferruginous sand		
2. Granular Iron-ore with streaks of ferric hydrate ..	20	0
3. Coarse, ferruginous, sub-oolitic Grits, in hard cherty bands, with *Am. decipiens*	2	6
4. Sands, weathering yellow, without fossils	2	0
5. Dark-green, earthy sub-oolitic Rock, highly charged with ferrous oxide	1	0
6. Dark ferruginous Sandstones, and intercalating hard beds, with casts of *Exogyra virgula*, and other fossils	10	0
	35	6

The following Fossils are found here and at Gorwell Road, a little beyond. Some species are very numerous, but chiefly as casts or fragmentary specimens :—

Ammonites decipiens, Sow.
„ *hector*, D'Orb.
Belemnites nitidus, Dollf.

Alaria.
Chemnitzia delia, D'Orb.
„ *ferruginea*, Bl. and H.
„ *Heddingtonensis*, Sow.
„ *pseudolimbata*, Bl. and H.
Natica eudora, D'Orb.
Nerinæa.
Pleurotomaria reticulata, Sow.
Pterocera.

Arca sublata, D'Orb.
Cardium delibatum. De Lor.
Inoceramus.
Modiola subæquiplicata, Goldf.
Myacites decurtatus, Phil.
Pleuromya Voltzii, Ag.
„ *tellina*, Ag.
„ *donacina*, Ag.

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* Messrs. Blake and Hudleston, p. 273.

Pinna pesolina, Cont.
Pecten Midas, D'Orb.
Trigonia monilifera, Ag.

Rhynchonella corallina, Leym.
„ *obsoleta*, Sow.
„ *inconstans*, Sow.
„ *pinguis*, Roem.
Terebratula insignis, Dav.
„ *ornithocephala*, Sow.
„ *subsella*, Leym.
Waldheimia lampas, Sow.
„ *Dorsetensis*, Dav.

Echinobrissus (*Nucleolites*) *scutatus*, Lam.

Glyphœa ferruginea, Bl. and H.

Serpula Royeri, DeLor.
„ *gordialis*, Goldf.

LINTON HILL, ONE MILE EAST OF ABBOTSBURY.—An escarpment of the "Corallian" there attains its greatest elevation, being at a considerably higher level than the beds at Gorwell Road, though belonging to a lower part of the series.

It contains a less amount of iron-ore, but fossils are more numerous and better preserved than in the before-named locality.

Ammonites plicatilis.

Chemnitzia Heddingtonensis.
Nerinœa.
Natica.
Pleurotomaria reticulata.

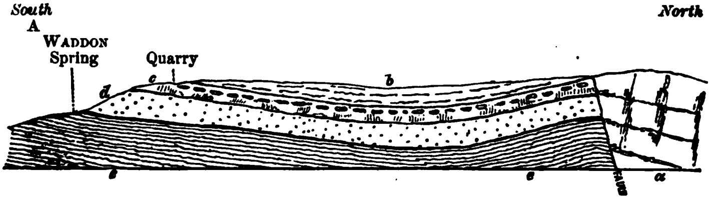
Anatina.
Goniomya v. scripta.
Myacites decurtatus.
Mytilus Jurensis, Roem.
Trigonia clavellata.

Terebratula.
Rhynchonella.

Acrosalenia decorata.
Echinobrissus (*Nucleolites*) *scutatus.*
Pygaster umbrella, Ag.

SECTIONS ILLUSTRATING THE RIDGEWAY FAULT.

Fig. 28.

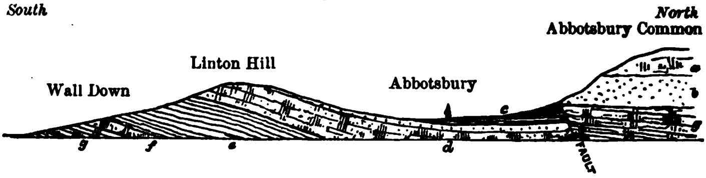


a. Chalk. *b.* Purbeck Beds. *c.* Portland Stone. *d.* Portland Sand. *e.* Kimeridge Clay.

From a section by Mr. Bristow in the published sections of the Geological Survey.

Fig. 29.

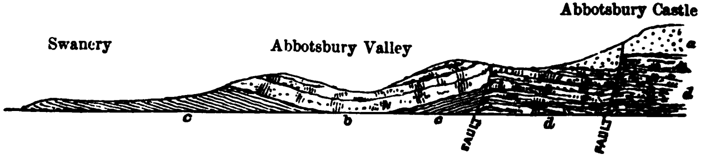
Section from Abbotsbury Common to the West Fleet.



a. Chalk. *b.* Upper Greensand. *c.* Kimeridge Clay. *d.* Coral Rag. *e.* Oxford Clay. *f.* Cornbrash. *g.* Forest Marble.

Fig. 30.

Section from Abbotsbury Castle to the Swanery.



a. Upper Greensand. *b.* Coral Rag. *c.* Oxford Clay. *d.* Forest Marble.

The three Figs. 28, 29, 30, are introduced to show the effects produced by the great Ridgeway fault in the course of its western extension. Of these Fig. 28 is copied from one of the Horizontal Sections of the Geological Survey, by Mr. Bristow, and represents the trough-shaped position of the strata on the south side of the fault, about half a mile east of where the Purbeck Beds finally terminate at Portisham. The Portland Stone is here brought up into immediate contact with the Chalk, which dips in a southerly direction, turning up again (as shown in the figure) with a gentle dip in the opposite direction so as to form a synclinal curve. Hence on the southern escarpment the Portland Stone and the Portland Sand make their appearance, dipping towards the fault, and resting on the Kimeridge Clay, which throws out a spring near its junction with the overlying sand. The Portland Stone occupies only a very narrow breadth where it is crossed by the line of section, and it gradually disappears at the surface altogether; the effect of the fault being to bring the overlying Purbeck strata into immediate contact with the Chalk for the remaining distance occupied by that formation in a westerly direction.

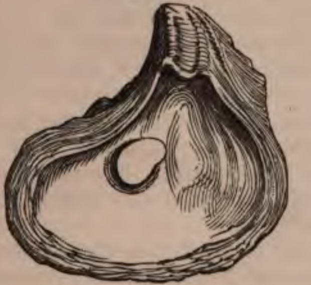
Fig. 29 represents the derangements in the strata produced by the fault between Portisham and Abbotsbury. In this interval the Chalk and Upper Greensand occupy the north side of the fault, and the lower part of the latter is brought into juxtaposition with the Kimeridge Clay, which abuts upon the fault on the south side. The Upper Greensand is here based upon clays belonging to the Forest Marble series, which make their appearance further west, occupying an acute triangular area between two faults, as is represented on the map of the Geological Survey and in the section, Fig. 30. The synclinal or trough-like position of the strata on the south side of the fault is still maintained, while the hard calcareous beds of the Coral Rag form the coast and the southern escarpment of Linton Hill, dipping towards the north, and passing beneath the Kimeridge Clay, which occupies the lower ground and extends to the line of fault. It must be mentioned here, however, that on approaching the fault the beds form a synclinal, and curve upwards towards the fault, from which they dip in a southerly direction to a greater degree and in a more marked manner than is represented in the diagram. The Chalk and the underlying beds north of the fault dip away from it at a small angle in the same direction.

Fig. 30 is a section of the strata taken on a line from the Swanery to Abbotsbury Castle. Although the synclinal position of the beds on the north side of the fault is still preserved, it will be observed that the Forest Marble and Cornbrash, which made their appearance in the last figure, are not seen here; but that the Oxford Clay is the lowest formation visible, while the Kimeridge Clay has also disappeared, and the Coral Rag is brought against the fault with a southerly dip. The great Ridgeway fault appears to have branched off here, and to have divided into two minor dislocations, the effect of which is shown on the maps of the Geological Survey. The effect of the disturbance has been to bring up the clays of the Forest Marble, here overlain by Greensand, and to place them in contact with the Coral Rag on the south. The second fault on the north traverses the Upper Greensand, letting the beds on the south down, and producing that false escarpment and broken under-terrace facing the true escarpment of the lofty ridge of Greensand and Chalk composing Abbotsbury Common, alluded to by Sir H. De la Beche and Dr. Buckland in their "Memoir on the Geology of the Neighbourhood of Weymouth." To this cause also are due the landslips and the confused heaps of débris which have fallen from the higher ground in some places, appearing like immense steps on the southern escarpments of the hill.

KIMERIDGE CLAY (Oak-tree Clay of Smith).

(Figs. of Fossils, see Supplement, Plates 6, 9, 10, 11, 12, 13, 14, 15, 16.)

Fig. 31.



Characteristic Fossil.
Ostrea deltoidea (flat oyster). Kimeridge Clay, Weymouth.

This formation occupies an important position in the geology of this district, where its thickness has been estimated by Dr. Buckland at 600 feet. Dr. Fitton gives only 300 feet ('Trans. Geol. Soc.,' vol. iv. p. 213. Mr. Blake has since measured the coast-section, as far as is accessible, and assigns to the beds a total thickness of 650 feet.*

In correlating the Kimeridge beds of Great Britain with those of the Continent, a division has been made into lower, middle, and upper, and thus designated :

Lower. Astartian zone, from the presence of *Astarte supracorallina*.
Middle. Pterocerian zone, from the presence of *Pterocera Oceani*.

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* 'Quart. Journ. Geol. Soc.,' 1875, vol. xxxi. p. 198.

In the Sub-Wealden Boring in Sussex, 1872-5, the Kimeridge Clay was found to be not only in excess of its estimated thickness, but of any thickness of this formation hitherto known.

Lists of Fossils collected from the boring and determined by Mr. R. Etheridge, as also the depth from the surface at which each specimen was found, are given in Mr. Topley's catalogue in the British Association Report for 1875, and in his chapter on the Sub-Wealden Boring in Dixon's Geology of Sussex, new edition, by Prof. T. R. Jones, 1878.

Upper. Not clearly defined, stress being laid upon the occurrence of *Trigonia gibbosa*, a fossil only found in Britain in the Portland rocks.

Dr. Waagen considers the chief development of the Kimeridge Beds to be in the middle region, which he terms the zone of *Exogyra virgula*. Other zones have been proposed on the evidence of certain fossils, but this test seems to fail when the area of observation is enlarged: thus *Rhynchonella inconstans*, which at Weymouth is characteristic of the lower beds, is in the vicinity of Montebeliard (France) found only in the upper and middle beds.

The classification of the beds as adopted by Prof. Judd,* and other English geologists, agrees in the main with that of Dr. Waagen, though Mr. Blake considers that the Kimeridge Clay of England should be divided into Upper, Lower, and Passage Beds.†

New sub-divisions of the "Kimeridgian," of the "Portlandian" above, and the Corallian below, have been proposed, but without, as far as can be judged, a final determination. See Papers referred to in the Preface.

From the coast of Dorsetshire the Kimeridge Clay extends inland, with little interruption, to the coast of Norfolk. It reappears on the opposite parts of the coast of France; in the Jura district, where it is dissimilar in mineral character, but is recognisable by its position and organic remains; in Medjansk, in Russia, where it offers the same shaly character as in Britain, and is so bituminous as to have been mistaken for a Coal-measure formation.

The bituminous and inflammable nature of a portion of the Kimeridge Clay, coupled with its use as a substitute for fuel at Kimeridge and the adjacent villages, has sometimes obtained for it the name of Kimeridge Coal.‡

When coals bore a high price, this stratum was regularly worked and sold at 9*d*. per hogshead, or 6*s*. a ton.§ Its bituminous nature may be derived from either animal or vegetable sources, both being ascertained to be present. Though tough when first quarried, it splits into thin laminæ after exposure to the atmosphere, and burns with a crackling noise and the evolution of a considerable amount of sulphureous vapours, at the same time giving out much heat. From this bituminous schist[*] in Holworth Cliff, Ringstead Bay, spontaneous combustion proceeded in the autumn of 1826, and continued for some years. Sulphuretted hydrogen was liberated, the odour of which could be detected for several miles under certain circumstances.

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* 'Quart. Journ. Geol. Soc.,' vol. xxiv. p. 214.

† From the absence of certain fossils which characterised the Middle Kimeridge of the Continent, and especially of *Pterocera Oceani*, this division is not supposed to be represented in England. 'Quart. Journ. Geol. Soc.,' vol. xxxi. p. 196.

‡ In chambers within the barrows of the Isle of Purbeck quantities of the shale have been found reduced to ashes.

§ 'Gentleman's Magazine,' vol. xxxviii., year 1768.

This phenomenon first made its appearance immediately after a spring-tide, which being attended with strong southerly gales, the waves broke over the cliff, and the water producing a decomposition of the iron pyrites in the shale was supposed to have been the cause of ignition. If we remember rightly, there had previously been a slip in the cliff, by means of which a fresh portion of it had become exposed. Whatever might have been the exciting cause, certain it is that when once ignited it received increased force from heavy rains or sea-water. The cliff continued in a burning state several years, during which period it formed an object of considerable interest. On acquiring fresh energy, it threw out volumes of dense and suffocating smoke which, from its specific gravity, seldom rose high into the air. This was followed by bluish flames, rising at times so far above the cliff as to be visible from Weymouth. Through the cracks spread over the surface by the ascending heat the burning stratum beneath was seen. The fissures and other openings were covered with deposits of sulphur. Some people expressed alarm at residing so near a supposed volcano, but we need scarcely say it was unattended with explosive noises, eruptions, and the other phenomena ordinarily accompanying volcanic action. The combustion only ceased when the inflammable portion of the shale was consumed.*

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[*] *Schiste* or *Bituminous Schistus*, the term applied on the Continent to this stratum.

[†] When sulphur and iron-filings (iron and sulphur being the components of iron pyrites) are mixed in large quantities and made into a paste with water, they gradually become so hot that ignition ensues. 'Brande's Chemistry.'

Mr. Cross, the late eminent electrician and chemist, informed me that in the course of his experiments he had found spontaneous combustion to ensue from pulverised limestone and iron pyrites mixed in clay and buried for a year or two.

During the distillation of the shale, a process hereafter to be explained, sulphuretted hydrogen gas is evolved, possessing considerable illuminating power.† With such an amount of the raw material as exists in the neighbourhood, a permanent supply of gas might be procured, sufficient for the lighting of Weymouth; and if, by some inexpensive process, it could be cleansed from the sulphur and other impurities, which render it not only highly offensive in smell, but destructive to retorts, it might be thus applied. Besides the Kimeridge Clay, there are interspersed throughout the oolite beds of shale and lignite sufficiently inflammable to form an imperfect kind of coal, which in many places is used as a substitute for that mineral. Their occurrence having been regarded as an evidence of the proximity of real coal, many fruitless and costly attempts to obtain this shale have been made in districts where coal could only exist at an unapproachable depth.*

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* Sir John Richardson says, in his 'Narrative of the Arctic Searching Expedition,' vol. i. p. 271: "At Cape Bathurst, lat. 75 N., bituminous shale is exposed in many places, and in my visit there in 1826 was in a state of ignition; and the clays which had been thus exposed to the heat were baked and vitrified, so that the spot resembled an old brick-field."

A similar ignition is recorded as having occurred in the Lias forming the cliffs at Charmouth: "There is in the lias cliff at Charmouth a good deal of pyrites, which took fire after a heavy rain, and produced an appearance of flame at a distance." This happened in the year 1751, and a second followed in the year 1755. 'Chemical Essays,' by Bishop Watson. Maton's 'Observations on the Western Counties.'

† It is from beds of bituminous shale like that of Kimeridge that under certain circumstances spontaneous inflammable gas is emitted. Capt. Beaufort describes one of these natural jets near the Deliktosh coast of Karamania. Similar gases are evolved at Taman, Kertch, and Tiflis. In the Chinese frontier of Tsetchuan such a gas has been economically applied for more than 1000 years. Bamboo pipes convey the gas from its source to the place where it is to be consumed. A single source of gas heats more than 300 kettles employed in evaporating saline water. Other bamboos conduct the gas intended for lighting the streets.

Referring to the inflammable shale of the Kimeridge Clay, Dr. Mills, a former Dean of Exeter, says, it is not unlike the bitumen of the Dead Sea, and that the smoke arising from it resembles that of the latter.—'Phil. Trans.,' vol. lxi. Dr. Pocock, 'Travels to the East,' vol. ii. p. 30, bears similar testimony.

In further confirmation of which I may add that specimens of bitumen coated with sulphur, which I gathered on the shore of the Lake, on being exposed in a flame, emitted an odour resembling that of the Kimeridge Shale when burnt.—R. D.

The products arising from the treatment and distillation of the shale, as set forth by a company† formed in Weymouth some years since, for the purpose of working it, are:—

First. A volatile oil or spirit, perfectly colourless, and transparent, chemically pure, and admirably adapted for lamps and all other purposes for which naphtha or camphine is applicable, and on account of its purity, has great advantage over other oils, gas, &c., as it will not tarnish the polish of metals, or spoil the colour of fabrics.

Secondly. A denser oil, having no tendency to become rancid, and capable of burning pure in ordinary oil lamps, or for use in manufactories, lighthouses, &c. This second oil will also dissolve in any proportion with seed or fish-oils, augmenting considerably the illuminating power and the time of burning, and prevents other oils from so soon becoming rancid and congealing by cold.

Thirdly. A fatty mineral oil, containing paraffine or spermaceti in large quantities, and particularly applicable for lubricating machinery, and has the advantage over other oils in preserving all its unctuosity whilst in contact with metals, and being incapable of becoming siccative or dry.

Fourthly. A mineral tar of a jet black, and capable of being used for all purposes of varnish, and preserving wood and metal.

Fifthly, and lastly. The carbonaceous residuum, after the extraction of the above products, forms a manure of the richest quality, and also a powerful disinfectant; to this manure is added the ammonia coming from the distillation of the schist, and all the alkaline grease (rich in azote and caustic alkali), remaining after the treatment of the oils.

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* Such trials have been made by sinking into this stratum at Sunning Hill, near Oxford, and at Farringdon in Berkshire. At Whiting's farm, near Shaftesbury, they sank by subscription upwards of 100 feet.—Later experiments, alike fruitless, have been made at Buckland, a village near Weymouth.

† This company, worked at considerable loss, was reconstructed on a more extended scale at Wareham; but this too has long since been relinquished, though another company is about to commence operations. Kimeridge, Ringstead, and Portland are the parts of the coasts which in Dorsetshire yield the shale in the greatest abundance.

Produce of the distillation, and treatment of fifteen tons of bituminous schist :—

93 gallons, No. 1, volatile oil in spirit.
42 gallous, No. 2, fixed oil.
28 gallons, No. 3, fat oil.
5½ cwt., mineral pitch.
10¾ tons of carbon-treated manure.
7 cwt. ditto of pitch, second treatment.

The best bands give an average of—

Volatile matter	19 per cent.
Carbon	19 „
Refuse or Ash, about	60 „

The "Short-joint Coal" is from 6 to 8 inches thick, and does not pay to uncover, while the two lower strata of coal, together with the intermediate rock, form seams 2 feet thick in the aggregate. The following analysis* of this coal has been given :—

	Parts of 100.
Volatile matter	50·9
Carbon	18·6
Ash	3·15

Mr. Bristow states that 11,300 feet of 20-candle gas can be produced from one ton, and further adds that it has a most abominable odour.

Compared with these results it may be mentioned that Boghead Coal, with which the "Kimeridge" has been compared, yields 15,480 feet of 52-candle gas.

The late Mr. Keats, consulting chemist to the Metropolitan Board of Works, gives the following report on the sample submitted to him for analysis :—

Cubic feet of gas per ton	9000
Illuminating power	16 candles
Volatile matter	61
Carbon or Coke	39
	100
The Coke contains Carbon	13·15
Ash	25·85
	39· 0

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* Report in *Times*, 8th April, 1874.

The Ash contains—Insoluble residue	29·01	per cent.
Peroxide of Iron	7·10	"
Silica	21·75	"
Alumina	10·60	"

Alum works formerly existed at Kimeridge. Alumina being the base of pure clay, it is found in all beds of shale.*

From the following notice of these early chemical works it appears that, besides alum, other products were also obtained, and the bituminous shale was employed as fuel. "The next place that offereth itself is *Smedmore*, where Sir William Clavile, descended of antiente gentrie, built a new house and beautified it with pleasant gardens. This place not long sithence had lordes of the same name, from whom it passed hereditarilie to the *Claviles*, neare adjoeining to the sea ; and not farre hence, the nowe owner beeing in diverse faculties, put in tryall the makeing of allom, which hee had noe sooner, by much cost and travell, brought to a reasonable perfection, but the farmers of the allom workes seized to the king's use; and being not soe skillful or fortunate as himselfe, were forced with losses to leave it offe, and soe now it rest allmost ruined. * * * * But in place of it *Sir William Clavile*, who one disaster dismayeth not, hath sithence sett up a glasse house (which is come to perfection, and is likelie to redounde to a good benefit) and salt-house. For transportation of these commodities, as alsoe of white salt (there is made in great abundance, by boyling it out of the sea water) hee hath at his owne charge, with great rocks and stones piled together, a little key, &c. &c." "They use a kinde of blueish stone that serve to burne, for maintaineing fire in the glass house; but in burning yields such an offensive savour and extraordinaire blacknesse, that the people labouring about those fires are more like furies than men."†

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* The alum-shale of the lias at Whitby is said to yield it in the largest proportion. The process is effected by means of roasting and lixiviation. When the iron pyrites of the clay is decomposed, sulphuric acid is produced, which, combining with the aluminous earth, forms sulphate of iron and alumina. This being purified by subsequent processes, the alum of commerce is formed. 130 tons of the Whitby shale produce one ton of alum. There are no data to show in what proportion the Kimeridge shale yielded this substance.

† 'Coker's Particular Survey of the County of Dorset.'

"20 Elizabeth grants the wood and lands of the Isle of Purbeck except

The ruins of buildings and heaps of ashes were, in the year 1748, the only remains left of the above-mentioned works.

Fig. 32 is a representation of the effects produced by the overlapping action of the Upper Greensand, and by the faults which have produced dislocations in the strata at Ringstead Bay. The Upper Greensand in that locality rapidly stretches over the edges of the underlying strata, in consequence of its unconformability to

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allum and cheyne silver to John Englebey for 21 years."—Hutchins' 'Hist. of Dorset.'

"All the allum houses and mines in the Isle of Purbeck were granted to Paul Pindar for 12 years."—*Ibid.*

NOTE. *Coal Money.*—To the antiquary the Kimeridge Shale is not without interest, as from it were made those curious and ancient relics known as *coal money*, which are found buried in the Isle of Purbeck. These are of circular shape, two to three inches in diameter, half an inch thick, flat on one side, on the other slightly concave, and moulded around the edge with from one to five holes near the rim, which, however, do not pass through the piece. They bear the appearance of having been turned in the lathe, and are generally found in quantity carefully placed a few feet below the surface, sometimes in urns, and very frequently in barrows associated with sacrificial and interred remains. At what period these relics, which have never been found in any other part of Great Britain, were produced is uncertain, but they are evidently the work of a very ancient people. Sir R. C. Hoare, who has written on the subject, ascribes their production to a colony who inhabited the site, neither Roman, nor British, but before both. ('Description of the Deveril Barrow.' Nicholls & Co., London, 1826.) The same obscurity exists as to their use, some supposing that they were simply tallies or the representatives of money, some that they formed an ancient sort of token money, while others again suppose that they were of some mystical use in sacrificial offerings or sepulchral rites. Besides these small circular pieces, large slabs of shale have been discovered, on which were traced circles and various other mathematical figures.

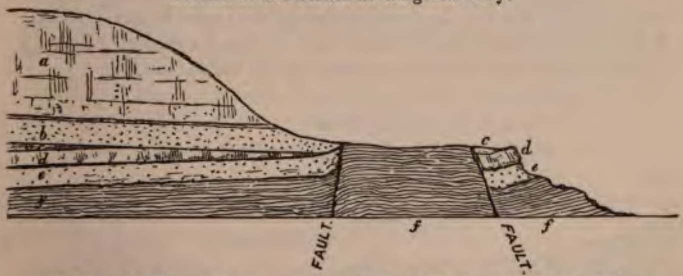
In the Celtic barrows near Weymouth armlets made from the shale are not uncommon. In the Roman Villa at Preston, adjacent to the Roman Temple at Jordan Hill, portions of a chequered pavement formed of black and white tesseræ were found, the former being apparently derived from the Kimeridge Shale, the latter from the limestone of the neighbourhood.

The Dorset County Museum in Dorchester contains a great quantity of the so-called "Coal Money;" as also vases, armlets, and other articles made from the shale.

them, as is apparent from an inspection of the geological map, in which the Upper Greensand is represented between Osmington and Boat Cove, as overlapping the strata from the Weald Clay and Hastings Sand formation to the Kimeridge Clay inclusive, in the short distance of a quarter of a mile. The section represented in Fig. 32 is taken in the direction of the dip from the sea-shore towards South Holworth. The fault nearest to the sea is a downthrow towards the south, bringing the Purbeck Beds *c* on the south side on a level with the Kimeridge Clay *f* on the north, at the same time tilting the strata so let down in the direction of the fault at an angle of 30°. The northernmost fault on the other hand is a downthrow on the north side, bringing the base of the Upper Greensand on a level with the Kimeridge Clay on the south side of the fault. Hence the combined effect of the two faults is to produce an elevation or upthrow of a lower formation (the Kimeridge Clay), between higher geological formations on either side of it. This locality derives an additional interest, apart from the geological phenomena which it exhibits, in having been the site of the pseudo-volcano of which a description has been given.

Fig. 32.

Section of the Strata at Ringstead Bay.

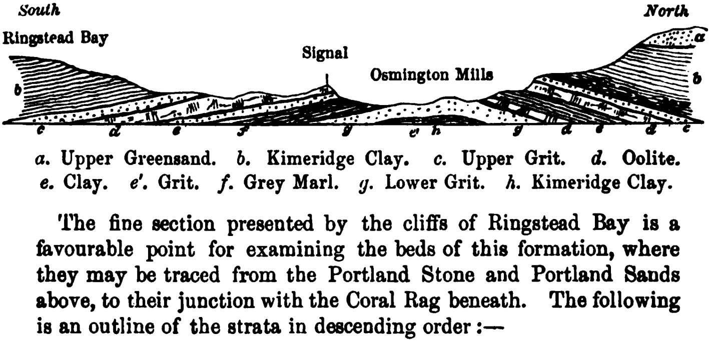


a. Chalk. *b*. Upper Greensand. *c*. Purbeck Beds. *d*. Portland Stone. *e*. Portland Sand. *f*. Kimeridge Clay.

The site of the pseudo-volcano generally presents a state of ruin, from the frequent land-slips and masses of stone detached from the overlying Portland Beds; but the baked shale, converted into a condition resembling fragments of burnt slates or over-burnt bricks, is still visible. On the shore, near the Portland ferry-bridge, Dr. Buckland described a portion of the Kimeridge Shale, now covered up with sand, and which then presented the appearance of slate burnt to the condition of red tiles; from the phenomenon that has since been exhibited in the same stratum of Kimeridge Clay, at Ringstead, he was strongly of opinion that such combustion may have there taken place.* Proceeding westward, the Kimeridge Beds merge into the grit of the Coral Rag, and no longer retain their oily and bituminous character, and peculiar odour, but pass into a coarse sandy state. This appears to be no uncommon condition of the lower part of the Kimeridge Clay which graduates insensibly into the Coral Rag beneath, as it does into the Portland Sands above. This bed may be denominated as the Lower Kimeridge Grit, it being so dissimilar to the other parts of this formation. Several of the fossils found here do not occur in the beds above.

Fig. 33.

Section across the Anticlinal at Osmington Mills.



a. Upper Greensand. *b.* Kimeridge Clay. *c.* Upper Grit. *d.* Oolite. *e.* Clay. *e'.* Grit. *f.* Grey Marl. *g.* Lower Grit. *h.* Kimeridge Clay.

The fine section presented by the cliffs of Ringstead Bay is a favourable point for examining the beds of this formation, where they may be traced from the Portland Stone and Portland Sands above, to their junction with the Coral Rag beneath. The following is an outline of the strata in descending order:—

1. Portland Beds.
2. Light-coloured fossiliferous sandy stone, about two feet thick, containing fishes' teeth and scales.
3. Succession of beds of dark, bituminous, and highly inflammable shale, impregnated with sulphur and containing iron pyrites, with septarian and other nodules.
4. The lower beds, which may be traced along the base of the low cliff westward, merge, as they approach the Coral Rag, into a coarse sandy state

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* 'Trans. Geol. Soc.,' ser. 2, vol. iv. p. 23.

as the Upper Kimeridge does into the Portland Sands above.* In this lower grit ("Passage Beds" of Blake) many of the fossils are Corallian in character. Referring to this bed, Mr. Blake says he has found no indication of it in districts where the Coral Rag is absent, as in Lincolnshire, but that "in the presence of that formation it is always developed." In the same Memoir the Author describes these beds as an "exact repetition of the series on the shore near Sandsfoot." The resemblance, however, is not so close when tested by fossils, which at Ringstead are more numerous both in individuals and species; it differs also lithologically, being at Ringstead a grey homogeneous sandy grit.

This bed has been a rich depository for fossils, as the following list will testify; but of late years the lower part of the cliff has been covered with shingle.

List of Fossils from the Lower Kimeridge ("Kimeridge Grit") or "Passage Beds" of Blake, West of Ringstead Bay:—

Fish.

Asteracanthus ornatissimus, Ag.
Teeth, Scales, and Coprolites of Fishes.

Crustacea.

Eryma Babeaui, Oppel.

Cephalopoda.

Ammonite sanceps, Rein.
" *biplex*, Sow.
" *Berryeri*, Les.
" *canaliculata*, Münst.
" *decipiens*, Sow.

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* On the coast of France, near Boulogne, left of the Harbour, this formation assumes the condition described as characterising the "grit" or "passage beds" at Ringstead. The argillaceous portion of the series is absent, and the entire formation consists of these beds of grit capped by Portland Stone, the Portland Sand being absent or obscure in character. The fossils, which are in great profusion, differ in species from those found on this coast. I observed, as the most numerous in the fallen masses on the shore—*Gervilliæ aviculoides*, *Lima pectiniformis*, *Trigonia*, *Unicardium*, *Perna*, *Gryphæa*, *Ostrea deltoidea*. The surfaces of the blocks are traversed with fucoidal markings, similar to those lying on the shore at Sandsfoot, near Weymouth.

Ammonites hector, D'Orb.
„ *mutabilis*, Sow.
„ *plicomphalus*, Sow.
„ *plicatilis*, Sow.
„ *pseudo-mutabilis*, De Lor.
„ *triplicatus*, Sow.
„ *serratus*, Sow.
Nautilus hexagonus, Sow.
Belemnites abbreviatus, Mill.
„ *var.*
„ *Blainvillei*, Voltz.
„ *explanatus*, Phil.
„ *nitidus*, Dollf.

GASTEROPODA.

Alaria, Sp.
Chemnitzia Heddingtonensis, Sow.
„ *Cæcilia*, D'Orb.
Delphinula nassoides, Buv.
Littorina pulcherrima, Dollf.
Natica eudora, D'Orb.
Phasianella striata, Sow.
Pleurotomaria reticulata, Sow.
„ allied to *Anglica*
Rostellaria Mosensis, Buv.
Turbo, Sp.
Turritella minuta, K. & D.

CONCHIFERA.

Astarte lineata, Sow.
„ *ovata*, Sow.
Anomia, Sp.
Arca rhomboidalis, Cont.
„ *Mosensis*, Buv.
Avicula Dorsetensis, Blake.
Cucullœa pectinata, Phil.
Corbis concinna, Damon.
Cardium pseudo-axinus, Thur.
„ *striatulum*, Sow.

Cardium pesolinum, Cont.
Exogyra nana, Sow.
" *bruntrutana*, Thur.
" *Monodi*, Dollf.
" *literata*, Sow.
Gervillia, Sp.
Gresslya, Sp.
Hinnites fallax, Dollf.
Homomya compressa, Ag.
Isocardia minima, Sow.
Lima pectiniformis, Schl.
Lucina substriata, Roem.
" *plebeia*, Cont.
Opis supra-jurensis, Cont.
Ostrea deltoidea, Sow.
" *gregaria*, Sow.
" *solitaria*, Sow.
" *læviuscula*, Sow.
" *intricata*, Cont.
" *Monsbeliardensis*, Cont.
Pecten arcuatus, Sow.
" *demissus*, Phil.
" *distriatus*, Leym.
" *Midas*, D'Orb.
" *Quenstedti*, Blake.
Pholadidea (*Pholas*) *compressa*, Sow.
Pleuromya donacina, Ag.
" *tellina*, Ag.
" *Voltzii*, Ag.
Pholadomya æqualis, Sow.
" *pelagica*, Ag.
" *paucicostata*, Ag.
Perna mytiloides, Lam.
Pinna lanceolata, Sow.
" *granulata*, Sow.
Thracia depressa, Sow.
Trigonia marginata, Damon.
(*monolifera*, Lycett.)
" *Meriani*, Ag.
Unicardium sulcatum, Leck.

BRACHIOPODA.

Rhynchonella inconstans, Sow.
Lingula ovalis, Sow.

ANNELIDA.

Serpula intestinalis, Phil.
„ *runcinata*, Sow.
Vermilia sulcata, Sow.

ECHINODERMATA.

Cidaris Blumenbachii, Münst.
„ *florigemma*, Phil.

CORALS.

Thecosmilia annularis, Flem.
Isastrea Greenoughi, M. Edw.

PLANTS.

Pinites dejectus.

The above list contains the following recurrent species:—*Pleurotomaria reticulata, Chemnitzia Heddingtonensis, Nautilus hexagonus, Ostrea deltoidea*, &c., while of *Trigonia clavellata*, which are massed in the Coral Rag immediately underneath, no example occurs.

UPPER KIMERIDGE, RINGSTEAD EAST.*

These high and almost vertical cliffs give, doubtless, the finest section of the Upper Kimeridge Beds anywhere presented. They consist chiefly of bituminous and inflammable paper-shale, which on exposure splits into very thin laminæ, covered with compressed fossils in countless numbers, of which the following are the prevailing species: *Ammonites*, many species; *Aptychi*, small and mineralised; *Lucina minuscula, Cardium striatulum*, and *C. orthogonale, Discina*

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* This is one of the few known habitats for *Pamphilia Actæon*, or Lulworth Skipper, a rare species of the diurnal Lepidoptera. It appears during the month of August for a period of from ten to fourteen days.

latissima, *Lingula ovalis*, *Alaria*, *Turbo*, with other indistinguishable forms.

Interspersed with the above shaly beds are indurated bands, Septaria, and other nodules.

These cliffs, and those between Sandsfoot and Portland Ferrybridge, have yielded a rich fauna of Kimeridge Clay Fossils, among which the following have been identified:—

SAURIANS.

Gigantosaurus megalonyx, Hulke.
Ichthyosaurus enthekiodon, Hulke.
Plesiosaurus brachistospondylus, Hulke.
Pliosaurus grandis, Owen.
Stenessaurus (*Plesiosuchus*, Owen) *Manseli*, Hulke, sp.
Steneosaurus rostro-minor, Geoff.
Teleosaurus megarhinus, Hulke.
Crocodilian (Teeth and bones).
Pterodactyle (Bones).
Dakosaurus (Teeth).

CHELONIA.

Pelobatochelys Blakei, Seeley.
Insect remains in Septaria.

FISH.

Asteracanthus lepidus, Dollf.
„ *ornatissimus*, Ag.
Aspidorhynchus, Ag.
Gyrodus coccoderma, Egerton.
„ *ornatissimus*, Blake.
Hybodus leptodus, Ag.
Ischyodus Egertoni, Buckl.
Lepidotus (very large species).
Pycnodus quincuncialis, Blake.
Sphærodus gigas, Ag.
Strophodus reticulatus, Ag.
„ *Normanianus*, Dollf.
Large Fish-Vertebræ.

CEPHALOPODA.

Ammonites anceps, Rein.
„ *biplex*, Sow.
„ *calisto*, D'Orb.
„ *eudoxus*, D'Orb.
„ *longispinus*, Sow.
„ *stephanoides*, Oppel.
„ *spinosissimus*, Damon.
„ *triplex*, Sow.
„ *triplicatus*, Sow.
Trigonellites (Aptychus) latus, Park.
„ (small sp.)
Nautilus (large species).
Belemnites abbreviatus, Mil.var.
„ *Blainvillei*, Voltz.
„ *explanatus*, Phil.

GASTEROPODA.

Alaria cingulata, Koch.
Cerithium.
Litorina muricata, Sow.
Turbo.

CONCHIFERA.

Astarte lineata, Sow.
„ *supra corallina*, D'Orb.
Avicula vellicata, Blake.
Arca, sp.
Cardium orthogonale, Buvig.
„ *striatulum*, Sow.
Corbis concinna, Damon.
Exogyra nana, Sow.
„ *virgula*, Defr.
Goniomya v. scripta, Sow.
Leda lineata, Blake.
Lucina minuscula, Blake.
Myacites recurva, Phil.
Modiola.
Ostrea deltoidea, Sow.
Pholadidea (Pholas) compressa, Sow.
Pecten.

Pinna.
Trigonia Voltzii, Ag.
„ *Woodwardi*, Lyc.
Thracia depressa, Sow.
Venus.

BRACHIOPODA.

Terebratula bisuffarcinata, Zeit. von Schlot.
Discina latissima, Sow.
Lingula ovalis, Sow.

CRUSTACEA.

Portions of

ANNELIDA.

Serpula intestinalis, Ph.
„ *runcinata*, Sow.
Vermilia sulcata, Sow.

ECHINODERMATA.

Cidaris florigemma, Phil.
„ *Blumenbachii*, Münst.
Ophioderma ?
Pentacrinus.

CORALS.

Thecosmilia annularis, Flem.
Isastrea Greenoughi, M. Edw.

Lignite. Crystals of Selenite. Iron Pyrites, largely diffused.

The above list includes fossil Reptiles, remarkable not only for their size and structure, but for the number of genera, and to which additions are still being made from time to time. Among others may be mentioned *Pliosaurus grandis*, Owen, of which the following portions were discovered at Kimeridge, by Mr. J. C. Mansel-Pleydell: Head (length of 7 feet 6 inches). Tooth (13 inches). Fore-paddle 6 feet 9 inches. The latter is in the new county museum in Dorchester.

OSMINGTON MILLS.

The Kimeridge Clay is here brought into a view by a fault on the shore, a little west of Osmington Mills, where it is capped with the Greensand. Portions of Pliosaurus have been found at this spot. In the cliffs above, and resting on the bituminous black band of the Kimeridge, is a layer of yellowish-white marly stone, 2 feet in thickness, very sparing in fossils, though containing *Discina latissima Fish Scales*, and *Palatal Teeth*. Above the layer in question are mottled clay-beds, with Septaria, and Cement stones. This stratum, different from all the other beds, may not readily be accepted as part of the Kimeridge. I have, nevertheless, no hesitation in assigning it to that formation, from having seen the Kimeridge of Hanover, a large portion of which is white and contains numerous Palatal Teeth of the genera *Gyrodus* and *Pycnodus*, with spines of *Asteracanthus* and other Kimeridge specimens. In the Lyons Museum there is a collection of Fossil Fishes from a cream-coloured slaty limestone referred to the Kimeridgian of that district.

KIMERIDGE VILLAGE, 14 miles east of Weymouth. The upper and more bituminous portion of this formation, between Chapman's Pool and Hen Cliff, supplied the material for the chemical works at Weymouth and Wareham.

These beds, which consist of alternating clays, shales, and indurated bands, have been carefully measured and tabulated by Mr. Blake; and show a thickness of 651 feet. Equally valuable is his Table, showing the distribution of all recorded Kimeridge Clay fossils, from the different districts of England, and of which the following is a summary. ('Quart. Journ. Geol. Soc.' vol. xxxi.) :—

NOTE.—Kimeridge Ledge is still the scene of frequent shipwrecks now, as it was in earlier times. In the reign of King Edward III., the privilege of wrecking was granted by royal lease to the Monastery of Cerne, and that the privilege did not remain dormant appears from a trial held at Sherborne during the reign of Henry VIII., in which it was shown that one Robert Kurlls, the owner of a wrecked ship, was wounded and maltreated, and that Thomas, "Abbot" of the Monastery of Cerne, had plundered the cargo and held the same for his own use at his Manor House at Kimeridge. ('Ancient Manor Houses of the Isle of Purbeck,' by T. Bond, Esq.)

	FROM ALL THE ENGLISH DISTRICTS. No. of Species.	WEYMOUTH DISTRICT. No. of Species.
Pterodactylus	1	1
Saurians	38	11
Chelonia	4	1
Fishes	15	12
Cephalopoda	26	18
Gasteropoda	29	16
Conchifera	111	79
Echinodermata	10	4
Annelida	8	4
Cirripedia	2	
Foraminifera	39	33
Plants	1	
Total	284	179

NOTE.—With the foregoing, the following summary of Fossils found in the Kimeridge Clay near Havre may be useful:—

Saurians	10
Chelonia	1
Fishes	6
Crustacea	3
Cephalopoda	9
Gasteropoda	19
Conchifera	73
Echinodermata	6
Zoophytes	1
Serpula	4
Total	132

(Faune Kimmeridgienne du Cap de la Hève, Havre; par Auguste Dollfuss.) Paris, 1863.

Mr. J. C. Mansel-Pleydell has favoured me with the following list of Fossils found in the Kimeridge Clay at Kimeridge:—

SAURIANS.

Ichthyosaurus enthekiodon, Hulke.
„ Sp.
Plesiosaurus brachistospondylus, Hulke.

Pliosaurus grandis, Owen.
„ *trochanterius*, Owen.
Steneosaurus (*Plesiosuchus*, Owen) *Manseli*, Hulke.
Steneosaurus rostro-minor, Geoff.
Teleosaurus megarhinus, Hulke.
Pterodactylus Manseli, Owen.
„ *Pleydelli*, Owen.

FISHES.

Gyrodus coccoderma, Egerton.
Lepidotus, Sp. (very large).
Sphœrodus gigas, Ag.

CEPHALOPODA.

Coccoteuthis latipennis, Owen.
Ammonites alternans.
„ *biplex.*
„ *triplex.*
„ *longispinus.*
Trigonellites (*Aptychus*) *latus.*

GASTEROPODA.

Alaria, Sp.
Littorina muricata.
Natica corallina.
Pleurotomaria reticulata.
„ Small species. ——

CONCHIFERA.

Avicula, Sp.
Astarte lineata.
Cardium striatulum.
Exogyra virgula.
„ *nana.*
Goniomya v. scripta.
Lima pectiniformis.
Lucina minuscula.

Myacites recurva.
Modiola cuneata.
Ostrea læviuscula.
Pecten lens.
Pholadomya æqualis.
  „ *oblata.*
Trigonia cymba.
  „ *incurva.*
  „ *Pellati.*
  „ *Woodwardi*, Lyc.
  „ *Voltzii.*
Pollicipes, n. sp.

BRACHIOPODA.

Discina latissima.

From the coast at Ringstead, the Kimeridge Clay passes through Preston, Upwey, and Portisham, to Abbotsbury, where the main mass terminates, the boundary line extending as far as the Church, and turning thence nearly in a north and south direction towards the fault. At the west end of the village, a small oval-shaped outlier, about a quarter of a mile long, and of half that breadth, rests upon the upper ferruginous beds of the Coral Rag, which have been already described.

Passing to another part of our district, the Kimeridge Clay rests upon the Coral Rag at Sandsfoot Castle, and thence extends westward to Portland ferry-bridge, from which point it turns to the south-west, and for a short distance forms the bank of the Little Sea that separates the Chesil Bank from the mainland.

SANDSFOOT.

The Kimeridge Clay series here are relatively as those west of Ringstead Bay, though they differ somewhat in their fossil contents. *Rhynchonella inconstans*, so numerous at Ringstead, and which may be considered the test of the lower Kimeridge Clay, is here absent, though *Ostrea deltoidea* and *Lima pectiniformis* are common in both places. The cliff beneath the old castle consists of sandy clays and various-coloured grits, more or less fossiliferous, but especially abounding in specimens of *Ostrea deltoidea*, which are massed in layers, largely contributing to the surrounding débris. The coarse ferruginous blocks on the shore are curiously marked with fucoidal casts and large specimens of *Lima pectiniformis* and *Pinna* (? sp.) in situ. The Kimeridge Clay and Coral Rag are here so thrown together, that the line of separation is almost undefinable.

The species of fossils which occur are included in the list of those found also in the "grit" beds at Ringstead.

In the cliffs between Sandsfoot and the Ferry-bridge, as also in the Kimeridge Clay on the N. E. shore, there is a quantity of Lignite similar to that found at Whitby. It is brownish-black to jet-black—brittle when dry, and breaking up into columnar fragments; smooth, and does not stain the fingers like coal. I have been favoured with the following analysis from the Museum of Practical Geology in London:—

LIGNITE from KIMERIDGE CLAY: WEYMOUTH.

	Per Cent.
Carbon	59·25
Hydrogen	4·91
Oxygen and Nitrogen	13·68
Sulphur	1·88
Ash	2·43
Water (Hygroscopic)	17·85
Total	100·00

	Per Cent.
Coke	30·74
Volatile .. .. Gaseous Matter	51·41
Water	17·85
Total	100·00

All Lignites contain a large quantity of water, even after long exposure.

* Here in Brick-fields (near the high-road) composed of brown and dark mottled clay, unlike any other deposits of the Kimeridge, but apparently belonging to the upper portion of that formation. These beds, coupled with the Portland Sand which is exposed in the road-cutting half a mile beyond, would probably be included in the Upper Bolanian of M. Pellat. The fossils found here, though of the Kimeridge Clay type, differ from the other beds of the Kimeridge formation. The following kinds prevail:—

Ammonites of two or three species. *Belemnites*, small species.
Lucina substriata, *Exogyra*, *Ostrea*, &c.

SECTION of the KIMERIDGE CLAY between SANDSFOOT and PORTLAND FERRY BRIDGE.

Ascending Order:—Base, upper calcareous grit—hard ledge covered with fucoidal markings, dipping south.

		Ft. In.
1.	Blue Clay, without fossils	12 0
2.	Hard Clays, yellow and red, used by the Portland Quarrymen to mark their blocks of stone. No fossils	3 0
3.	Brownish-coloured Clays. Fossiliferous	4 0
4.	Hard band of light-grey colour stony-bed. No fossils	4 to 6 in.
5.	Light-coloured Blue Clay. No fossils	3 ft.
6.	Dark Blue gritty Clay. Answers to the bed in the low cliff, west of Ringstead Bay. Fossiliferous	2 ft. 6 in.
7.	Blue Clay, having two separate layers of *Ostrea deltoidea* in masses, separated by another bed, with occasional specimens. Fossiliferous	20 0
8.	Hard Shale cracked, enveloping Septaria, not exceeding 12 inches in diameter	1 0
	Blue Clay	3 0
	Hard Shale, crowded with Septaria	1 6
	Blue Clay	1 0
9.	Soft Blue Clay, *Ostrea deltoidea* and other fossils	
10.	Gritty Clay. Fossiliferous	3 0
11.	Soft Blue Clay. No Fossils	4 0
12.	Gritty Clay, remarkable from the absence of adult specimens of *O. deltoidea* and the large number of small specimens. Gigantic Saurian remains have been found in this bed. Among others, *Gigantosaurus megalonyx*, Hulke	3 0
13.	Soft Clay, dark colour, covered with nacreous impressions of Ammonites as at Ringstead. Fossiliferous	30 0
14.	Layer of large flattened Septaria, under which Saurian remains have been found	
15.	Soft Blue Clay. Fossiliferous	20 0
16.	Another layer of Septaria in harder clay with Selenite. Contains Saurian bones	2 0
17.	Soft brownish coloured Clays	10 0
	Total Approximate Thickness	140 feet.

Abundance of lignite occurs throughout the above beds.

Besides the fossils referred to particular beds, there have been found Saurian and Turtle Remains; Palatal and other Teeth of Gyrodus, Strophodus, Lepidotus, Asteracanthus, &c. &c.; but the piling and walled embankment, built to secure the line of rails, now conceal the greater part of the section.

PORTLAND.

At Portland, the Kimeridge Clay having been raised with the superincumbent beds, crops out in its natural position immediately beneath the Portland Sand, extending on the east to Pennsylvania Castle, and on the west side of the Island to the Black Nore; though from the great accumulation of débris on the shore, it is but little exposed. It forms the substratum of the Island, as well as also the anchorage-ground of the Portland Roadstead; and there are evidences of its existence beneath the Chesil Bank, when a ground sea removing the shingle on the shore exposes the stratum of blue clay beneath. The wells for supplying fresh water to the convict and other establishments on the Island are sunk into the Kimeridge Clay; in connection with which we may observe that after a drought it sometimes happens that rain falls on the mainland before it does on the Island. This is indicated by the rising of the water in the wells, showing that the main source of the springs is beyond the Island.

At the Verne, or north end of the Island, loose stones and rubble cover bands of bituminous shale rich in oil and other products, which a few years since were quarried for chemical treatment. A bed of the shale presenting the appearance of burnt tile is exposed at extreme low water on the shore at Portland, near the Castle and extending to the north side of the Chesil Bank, from which the bituminous parts have been exhausted or burnt out. This altered character resembles the condition which was presented in the cliff at Ringstead, after the memorable combustion that occurred in the year 1826. As the shale could not have ignited without oxygen, no explanation appears more probable than that the bed in question must at one time have been above the level of the sea. The fossils found in this singular bed are similar to those of the paper-shales at Ringstead, compressed *Ammonites*, *Discina*, *Cardium*, *Astarte*, *Lucina*, *Pecten*, &c., though not always distinguishable.

ISLAND OF PORTLAND.

Dr. Fitton, in the Memoir already quoted, says, "that few places, probably, in the world exhibit with such clearness, and in so small a space, phenomena of more extraordinary interest, or of greater importance to theory." In geographical extent the island is four miles in length, and in its widest part one-and-a-half miles in width. On the north end it rises at the Vern to a height of 495 feet,* but slopes so rapidly in a southerly direction,† that the Bill or southern termination is but twenty feet above the level of the sea at low-water mark. The Portland Beds, on the east of Weymouth Bay, dip towards the sea in a similar manner. The strata forming the highest point correspond to those seen at the level of the sea at Durlestone Head.

The Portland Beds, which include the marine limestone and subjacent sand, are not a widespread formation. They occur in Wilts, Oxfordshire, and Buckinghamshire, but are scarcely represented in the Oolitic Series of the north of England. They are very fully developed on the French coast near Boulogne; also in Hanover; and M. Élie de Beaumont considers that he has recognised them in Burgundy,‡ and M. de Dufrenoy in the neighbourhood of Angoulesme.§ There is a singular uniformity in the elevation of the Portland Beds in the districts named. Brill Hills, on the borders of Buckinghamshire and Oxfordshire, exhibit the greatest elevation attained by this formation, viz. 550 feet, the Portland Beds being near the summit-level. At Shotover Hill, which is 560 feet above the sea, they are 50 feet below the summit.* At the Ridgway, over the villages of Preston, Chalbury, and Bincombe, they attain an elevation of about 500 feet. The Isle of Portland at its highest point is 495 feet.†

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* Extract from Drayton's 'Polyolbion:'—

"Where Portland from her top doth over-peere the maine,
Her rugged front empal'd on every part with rocks,
Tho' indigent of wood, yet fraught with wooly flocks;
Most famous for her folke, excelling with the sling,
Of anie other heere this land inhabiting,
That herewith they in warre offensivelie might wound,
If yet the use of shot, invention had not found."

† The exact direction is towards a point 48° E. of South.—See Geol. Survey Map.

‡ 'Annales des Sciences Nat.,' vol. for 1829.

§ 'Annales des Mines,' vol. ii. p. 434.

The Portland strata are seldom horizontal. In the counties referred to they dip slightly to the south. In the Isle of Purbeck, where they form part of the highly inclined and contorted strata which constitute that district (as may be seen in the cliffs east of Lulworth Cove, and throughout the whole range of high land to the westward extending to Portisham), they are elevated to an angle of 45° dipping to the north. At Portland they incline to the south. This inclination in opposite directions forms a portion of the Weymouth Saddle.

BED 16.—PORTLAND SAND.

The Kimeridge Clay is separated from the Portland Stone by a stratum to which Dr. Fitton applied the name of "Portland Sand." The latter is not to be confounded with those layers of loose sand which at Swindon alternate with the solid limestone above, and form an integral part of the Portland Stone series, with which they are identical in composition, except as regards the absence of the calcareous or cementing ingredient.

It has been proposed by some continental authors to apply the name "Bolonian" (Upper and Lower) to the beds from the Middle Portland inclusive, low down in the Upper Kimeridge Clay at a line not yet defined, while others include with the Portland Sand the upper portion of the Kimeridge Clay as "Lower Portlandien." Mr. Blake, not accepting either of these propositions, considers nevertheless that the Portland Sand has more affinity with the 'Kimeridgian' than with the 'Portlandian' series; and he thus summarises his views: "While the true Kimeridge Clay has very little in common with the Portland Stone, it has much with the Portland Sand, and the latter has as much with it as it has with the Portland Stone.‡"

The Portland Sand is of a bluish-grey colour, containing grains of green earth (glauconite) ascertained by Dr. Turner to be of the same composition as those of the Greensand formation, which underlie

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* Conybeare and Phillips' 'Outlines of the Geology of England and Wales,' p. 183.

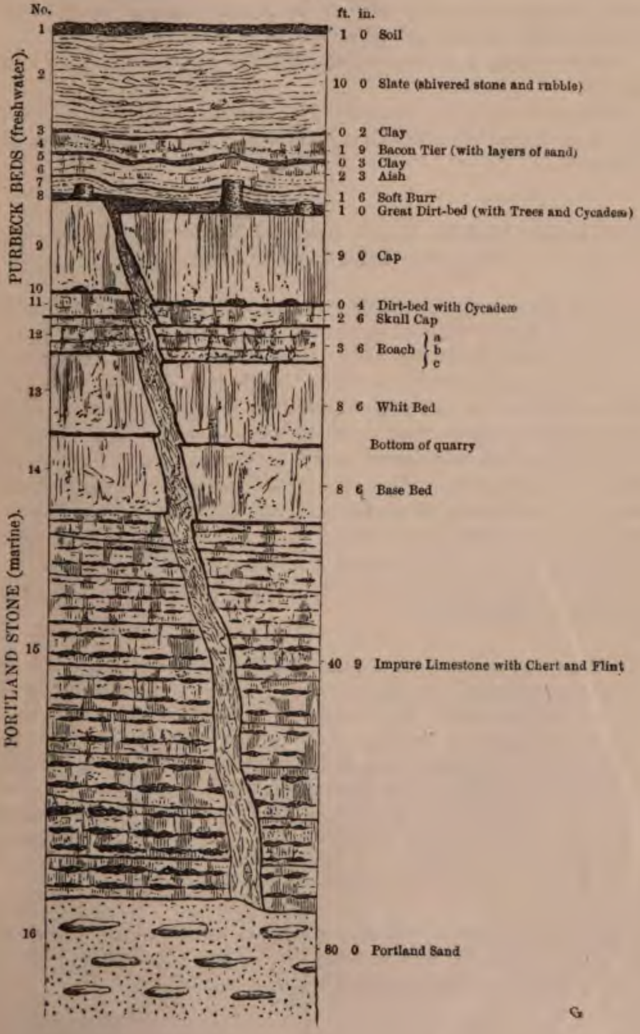
† The beds have a similar elevation near Boulogne.

‡ 'Quart. Journ. Geol. Soc.,' vol. xxxvi. p. 224, 1880.

Section of Quarry, Isle of Portland.

By H. W. Bristow, F.R.S.

Fig. 34.


No.
ft. in.
1 — 1 0 Soil
2 — 10 0 Slate (shivered stone and rubble)
3 — 0 2 Clay
4 — 1 9 Bacon Tier (with layers of sand)
5 — 0 3 Clay
6 — 2 3 Aish
7 — 1 6 Soft Burr
8 — 1 0 Great Dirt-bed (with Trees and Cycadeæ)
9 — 9 0 Cap
10 — 0 4 Dirt-bed with Cycadeæ
11 — 2 6 Skull Cap
12 — 3 6 Roach a b c
13 — 8 6 Whit Bed
Bottom of quarry
14 — 8 6 Base Bed
15 — 40 9 Impure Limestone with Chert and Flint
16 — 80 0 Portland Sand
PURBECK BEDS (freshwater).
PORTLAND STONE (marine).

the Chalk. Though originally deposited in the form of silt or sand, the sand of the Portland Beds, by pressure of the superincumbent strata,* has become consolidated to its present compact state, more resembling the texture of hard chalk than that of loose sand.

In some places it is more sandy, and the particles are then less cohesive.

At Black Nore, on the west side of the Island, it is interspersed with sandstone and other concretions, and swells out to a thickness of 80 feet.

PORTLAND SAND. BLACK NORE. WEST SIDE OF PORTLAND. ESTIMATED THICKNESS, 80 FEET.

A few years ago this conspicuous and well-known cliff presented a fine and almost vertical section of the Portland Beds, from the Purbecks to the Kimeridge Clay. It is now in great part concealed by the enormous amount of quarry débris here disposed of. The Kimeridge Clay at the base passes into a blue sandy marl with which the Portland Sand may be said to commence. This is succeeded by lighter-coloured sandy beds, with layers of the small *Exogyra bruntrutana;* above which the beds are of a more mixed character, containing Cement Stones, and other nodules, yielding a few fossils. Finally, the Portland Sand formation is capped with the lower, impure, shelly limestone of the true Portland Series.

The Portland Sand near the Vern Fort is argillaceous, and may be termed "Portland Clay."

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* The effects produced by superincumbent pressure on strata composed of loose materials has been illustrated by some experiments conducted by the late Mr. Brockedon. The best description of graphite having become scarce, he collected the dust formed in sawing the solid graphite into the oblong parallelopipeds required in the manufacture of drawing pencils. After being repeatedly sifted, the dust was then placed under a powerful press and subjected to a succession of heavy blows, exercising a pressure equivalent to the weight of 1000 tons. The result was the production of a graphite, or black lead, in a solid form, and sufficiently coherent to break with a conchoidal fracture.—'Quart. Journ. Geol. Soc.,' vol. ii. p. 31.

The pressure upon a stratum at a depth of five miles, would be equal to 120,000 lbs. to the square inch.—Dr. J. Evans' Presidential Address, 'Quart. Journ. Geol. Soc.,' June 1875.

The fossils, chiefly casts, found in the above localities, are:—

Ammonites biplex, Sow.
" *Boisdini*, De Lor.
" *giganteus*, Sow.

Natica incisa, Blake.

Avicula Octavia, D'Orb.
Arca.
Cyprina implicata, De Lor.
" *elongata*, Blake.
Cardium dissimile, Sow.
Exogyra bruntrutana, Thurm.
" *nana*, Sow.
Isocardia.
Mytilus autissiodorensis, Cott.
Lima Boloniensis, De Lor.
Ostrea.
Pleuromya tenera, Ag.
Pecten lamellosus, Sow.
" *solidus*, Roem.
" *Morini*, De Lor.
Thracia.
Trigonia incurva, Benett.
" *muricata*, Goldf.
" *Pellati*, De Lor.

Discina Humphresiana, Dav.
Rhynchonella Portlandica, Blake.

Serpula gordialis, Schl.

At Corton, two miles west of Upwey, Portland Sand fossils are more abundant. The precise spot is a short cutting, near, and on the north side of, a farm and dairy-house where the following fossils occur chiefly in casts. The bed is characteristic of the formation, and is sufficiently compact to present a vertical face.

List of Fossils at Corton Cutting:—

Ammonites biplex.
Belemnites.
Avicula.
Cardium dissimile.

Exogyra nana.
Lima rustica.
Ostrea.
Perna.
Pecten lamellosus.
„ *solidus.*
Trigonia gibbosa.
„ *incurva.*
Thracia tenera.

ST. ALBAN'S HEAD.

This notable landmark, 18 miles east of Weymouth, is more easily reached from Swanage. Dr. Fitton estimated the thickness of the Portland Sand here at 120 feet.

Mr. Blake, by including a portion of the lower beds, probably not regarded by Dr. Fitton as belonging to the Portland Sand, estimates them at 244 feet, or 124 feet in excess of that at the Black Nore.

The following summary, taken by Mr. Blake, of the section at St. Alban's Head, where the Portland Sand attains its maximum development, will show how this conclusion is arrived at :—

		feet.
Beds 1–9.	Portland Stone (Building Stone)	66
10.	„ „ Flinty Series	50
11.	Portland Sand. Mixture of liver-coloured sand, clay, and sandy cement-stones	39
12.	Dark sandy clay, with many bands of small cement-stones,	42
13.	Strong band of cement-stone : abundance of *Thracia tenera*	2
14.	Indurated sandy marl, with *Rhynchonella Portlandica* ..	30
15.	Mass of thicker Cement Stone	5
16.	Portland Sand ; line of separation between this and the Kimeridge Clay is uncertain. Low down in this bed *Lingula ovalis* is abundant	126
Thickness of Kimeridge Clay from the bottom of bed No. 16 to the base of the cliff		173

The beds are less fossiliferous than those at Corton and Portland, but the following are found :—*Ammonites biplex*, *Exogyra bruntrutana*, *Lingula ovalis*, *Mytilus autissiodorensis*, *Rhynchonella Portlandica.*

In the Portland Sands at Gad Cliff, near Kimeridge Bay, has been found the only known British example of *Trigonia cymba*, Cont.

NOTE.—Since the publication of the important Papers on the Portland and other Jurassic rocks of England, by Messrs. Blake and Hudleston, a Memoir on the "Parallelism of the Hanoverian and English Upper Jurassic Formations" has been published by Dr. C. Struckman, and communicated in substance to the 'Geological Magazine' (Ser. 2, vol. viii. pp. 546-57, 1881), by the translator, Mr. W. S. Dallas, which will be of interest to students of the Dorset and English Upper Jurassic beds. The author, by means of tables, shows that 125 species of fossils are common to the English and Hanoverian Upper Jurassic series. Further, that the Hanoverian Kimeridge formation contains all the species common in the Portland Stone, with the exception of *Ammonites gigas;* while several species common in our Portland Stone are, near Hanover, found exclusively in the Kimeridge beds. A still more curious fact is that *Ostrea deltoidea*, which in England begins with the Upper Corallian beds, and attains its climax of development in the Lower Kimeridge, is in Hanover exclusively confined to the Coralline Oolite. Again, while in the Kimeridge Passage-beds of England, Coralline Oolite forms prevail, in Hanover they bear more the character of the Kimeridgean Fauna.

PORTLAND STONE SERIES.

For Fossils, see Supplement, pl. 7 and 8.

BED 15 (see section, p. 81).—This, the lowest of the solid beds of the Portland Series, is (apart from its almost inaccessible depth) of little value for building-purposes, owing to the quantity of chert and flint associated with it.

The situation in the Island where this extensive formation can be most conveniently studied, is at the "Vern Ditch," a deep cutting surrounding the fortifications on the north-east side, where a fine section of 75 feet in vertical depth is to be seen, consisting of:—

Soil..	
Rubble and Cap	20 feet
Roach	14 „

Impure stone with flinty masses, 35 to 40 feet. The Roach. though so remarkably persistent in other parts of the Island, here swells out to much more than its usual thickness, and presents striking differences.*

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* Possibly this might be another bed of Roach, lower in the series than the Roach met with in the Quarries.

The common "Screw," *Cerithium Portlandicum*, so characteristic of the Roach, is almost entirely absent, while on the other hand *Perna mytiloides*, which is rarely found in any of the quarries, is numerous. The portion below consists of limestone, interspersed with chert and flint, occasionally occurring in layers, but more frequently in nodules or patches.* The whole series is much shattered, and yields no good building-stone, though it furnished material for the construction of the Portland Breakwater.

LIST of FOSSILS that have been collected in the Vern district:—

Saurian remains.

Crustacea.

Ammonites giganteus.
„ *biplex.*

Buccinum.

Cardium dissimile.
Cyprina.
Lithodomus Portlandicus.
Modiola pallida.
Ostrea expansa.
Perna mytiloides.
Trigonia gibbosa.
„ *incurva.*
Unicardium.

Isastræa oblonga (covering casts of *Lithodomi*).

In the Museum of the Royal Engineers' Office at the Vern works, there is a well-preserved portion *in situ*, of the skeleton of Plesiosaurus.

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* Analogous to the chalk-flints. The deposit of two kinds of matter, *silica* and *carbonate of lime*, from the same waters, or from a soft mass, is due to the tendency which similar particles of matter have to accumulate in nodules or in certain planes, of which there are examples in very many formations. The original soft condition of the flint is proved by the fossilised casts of organisms which are contained within its matrix.

BEDS OF BUILDING STONE.

BED 14.—BASE BED, or LOWER TIER.—This, from its greater depth, is not so generally worked as the beds to be hereafter described. Compared with the layer above, it is whiter in colour, finer in grain; more absorbent, and softer. This latter property, while it lessens its value for outside work, increases it for statuary and interiors. In some quarries this bed has been worked to a great extent, and sold for the best stone.

At Upwey and Preston the corresponding bed is known as the "White Freestone." In North Wilts the same bed is white, like ordinary chalk; and in the Vale of Wardour, one stratum of Portland stone bears so close a resemblance to common chalk, as to be called by that name.

In the Portland Beds in the Island of Purbeck, there is overlying the freestone a layer of oyster shells (*Ostrea solitaria*), eight feet in thickness cemented together into one mass. This bed may be seen in the cliffs at Tilly Whim.

A middle or "curf" bed occurs between the two tiers of good stone, but only in the southernmost quarries on the east cliff. The entire thickness of stone, though thus divisible, is not thereby increased.

In the Grove Quarry (Red Croft), the "curf" is divided by a band of oyster shells, about 15 inches from the top, and by a second band 2½ feet below the upper. It is an oolitic stone, soft in a northerly direction, but harder towards the south. The bed is of superior quality to the adjacent freestone, but like all the beds containing flint, or lying adjacent to it, it will not stand exposure to the weather.

Fig. 35 represents some fossil remains found in the "curf" bed, which I believe are peculiar to the Island of Portland; but where, in quarries on the north-east side of the island, they are not uncommon. They appear to be casts of *Lithodomi* (a genus of boring mollusc) encased in stone, the surface of which is generally covered with a coral—probably the *Isastræa oblonga* (Plate 8, Fig. 10). Their curious position, more or less erect, as if growing out of the stone, and grouped as above, may be explained by an examination of a portion of rock taken from low-water mark, which has been pierced by *Pholadidæ*, the perforations of which will be found to be nearly perpendicular to the surface. In the case of the Portland Oolite sea-bottom, it would seem that these perforations containing

Fossils from the Portland Stone, Island of Portland.

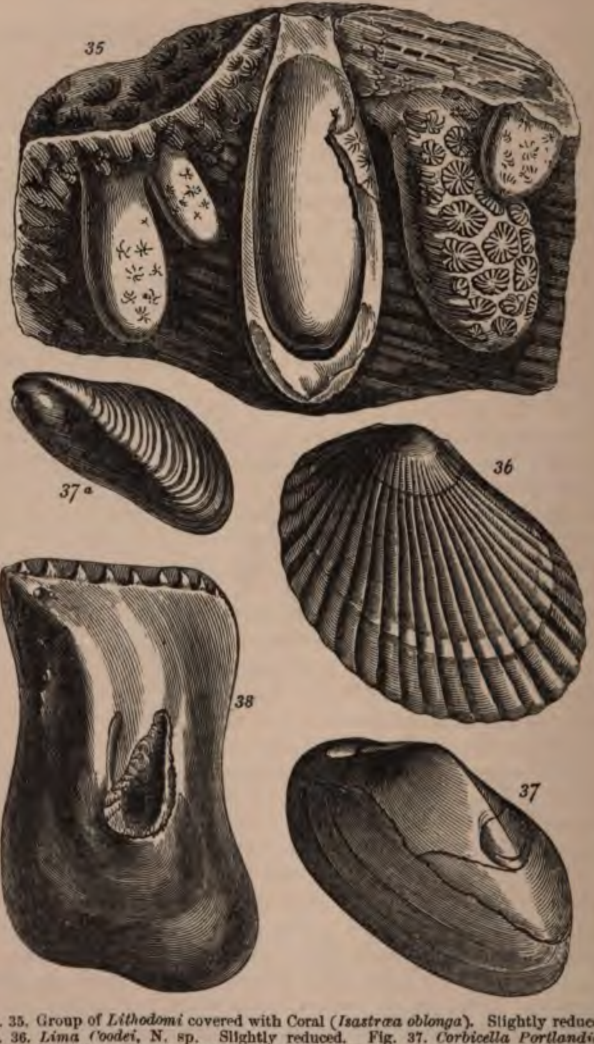

Fig. 35. Group of *Lithodomi* covered with Coral (*Isastræa oblonga*). Slightly reduced. Fig. 36. *Lima Coodei*, N. sp. Slightly reduced. Fig. 37. *Corbicella Portlandica*, N. sp. Nat. size. Fig. 37*a*. *Modiola pallida*. Nat. size. Fig. 38. *Perna mytiloides*. Reduced.

the shell became filled with a stony sediment, not only *within* the valves but on their outside, filling the space between the shell and its walls. The intervening portion of the rock or clay thus burrowed, having disappeared after the filling up and consolidation of the casts, the latter alone remained; a careful removal of the coating will sometimes expose an impression of the hinge and contour of the shell. The presence of corals and lithodomi are evidences of a shallow sea.

BED 13.—WHIT BED OR UPPER TIER.—This bed, the best stone that the Island produces in point of quality, is a whitish-brown, when raised, but becomes paler on parting with its quarry-water. It is free from shells and hard veins, though varying in texture from a fine close grain to an oolitic or roe-like structure. The bottom part of the Whit Bed in the west-cliff quarries is observed to be softer towards the south. It is from this Upper Tier that most of the stone quarried in the Island is obtained. The depth as well as the quality, both of this and the Lower Tier, differ considerably in the various quarries, and sometimes in the same quarry. Both exist to a greater depth in the west cliff quarries than those of the east cliff. The north-east part of the Island is considered to yield the best quality of stone. The stone of each Tier is said to be hardest towards the upper part. The workmen profess to know the quality of the stone by the sound which follows the stroke of a hammer; the best blocks ringing with a clear musical note.

On the surface of the Whit Bed in the Kingbarrow quarries, and usually separated from the Roach above by a flint layer, are patches of a fine débris containing numerous minute but well-preserved shells, which I have not seen in other parts of the Island, neither do they appear to have been noticed elsewhere in Great Britain. They are not included in Mr. Blake's table of the Portlandian fossils. On comparing these fossils with the species figured and described by MM. de Loriol and E. Pellat in their important work of 'L'Etage Portlandien des Environs de Boulogne,' I recognise the following species not hitherto referred to Great Britain:—

Cerithium Carabœufi, De Lor.
„ *septemplicatum*, Rœmer.
Delphinula vivauxea, Buv.
Nerita Micheloti, De Lor.
Odostomia jurassica, De Lor.
Orthostoma Buvignieri, De Lor.
„ *granum*, De Lor.
Pseudomelania paludinœformis, De Lor.

Serpula coacervata, Blum.
Tornatina Oppeliana, De Lor.
Astarte.
Cardita Boloniensis, De Lor.
Mytilus Morinicus, De Lor.

Spines of Echinidæ.
Spicules of Sponges.

The weight of a cubic foot of the Whit Bed, from Vern Quarry, is 134 lbs. 10 oz.

The price at the quarry, squared and ready for shipment, is 1*s.* 4*d.* per cubic foot,[*] or 20*s.* per ton. The same sells in London for 2*s.* 3*d.* per cubic foot. Being in continuous beds, blocks of almost any dimensions may be procured.

ROACH.—BED 12, *c.* hard, somewhat silicious and bituminous bed, but so crowded with casts of shells as to be unsuited for architectural purposes, though, from its great durability,[†] it is admirably adapted for quay-walls and other uses where a smooth surface is not necessary. In its native bed it is incorporated with the good stone lying below, which in working is separated from it.

Blocks of any practical size can be produced. The weight of a cubic foot of Roach, taken from Goslings Quarry, is 126 lbs. 13 oz.[‡] The price at the quarry is 6*d.* per foot, or 8*s.* per ton.

The Roach does not offer the same character out of the Island.[§]

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[*] In the year 1700 it sold for 9*d.* a cubic foot. In that year 9000 tons of stone were shipped from the Island.

[†] Its suitableness for fortification purposes was tested in the Isle of Portland. Blocks of the Roach and others of Cornish Granite being exposed to the fire of heavy guns from H.M.S. Blenheim, it was found that the former broke up more readily than the latter.

[‡] Specific Gravity of / Weight per square foot.

Specific Gravity of		Weight per square foot.
Chalk	1·704 ..	114 lbs.
Bath Oolite	1·839 ..	114 „
Portland Stone ..	2·145 ..	134 „
Aberdeen Granite .	2·625 ..	164·06 „

(Willich's Tables.)

[§] At Swindon the Portland Stone is not so uniformly capped with the Purbeck or Freshwater Limestone as in the Isle of Portland, which may explain the difference of the two formations. The Portland area when raised from the sea became the bottom of a fresh-water lake, whence it received a calcareo-siliceous deposit, which Cuvier and Brongniart have observed as characterising the waters of ancient lakes. This has enveloped and cemented into one mass accumulations of marine shells (Portland roach); that in Wiltshire appears to have been raised so as to form

As none of the species of fossil shells found in the Roach occur in any later formation, it may be presumed they became extinct in this area when that bed was raised out of the sea. The casts, though so abundant, rarely retain a vestige of the shell, the original of which, after the consolidation of the mass, decomposed, leaving an empty cavity, and an impression of its outer shell upon the surrounding matrix. All that remains, therefore, are casts of the inside of the original shell, which correspond to what may be produced by filling a recent shell, and afterwards surrounding it with plastic matter; when it had undergone the process of hardening, and the shell became decomposed, there would be remaining:—an interior cast presenting a counterpart of the animal which inhabited the original shell; an impression on the surrounding mass corresponding to the markings of the external surface. Figs. 2 and 3, Plate 7.

b. Layer of flint, in which occur the same species of fossil shells as those found in the bed below. These fossils, which occur on the surface of the flint, retain their outer shells, which are replaced by Chalcedony.

a. The upper portion, for a few inches in depth, has an oolitic structure and uniform texture, light-brown colour, and is free from fossils.

The chemical composition of the Top Bed of the Portland Stone, as analysed by Professor Daniell, is:—

Silica	1·20
Carbonate of Lime	95·16
Carbonate of Magnesia	1·20
Iron and Alumina	0·50
Water and Loss	1·94
Bitumen	a trace
	100·00

The prevailing fossils of the Roach[*] are:—*Trigonia gibbosa,*

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dry land, since in that district a bed composed almost entirely of casts of shells, like those of the Portland Roach, forms there a loose and incoherent mass.

[*] The corresponding bed in Wiltshire contains nearly the same species as at Portland, but differing in their relative proportion.

Near Boulogne, the utmost known limit of the Portland series, the

Cerithium Portlandicum, Lucina Portlandica, Buccinum naticoides, Natica elegans, Pecten lamellosus, Ostrea expansa, Plicatula, Sowerbia Dukei.

FOSSILS from the PORTLAND STONE, Isle of Portland:—

VERTEBRATA.

Plesiosaurus megapleuron, Owen.
Pycnodus Bucklandi, Ag.
Pycnodus pagoda, Blake.
Hybodus strictus, Ag.

CEPHALOPODA.

Ammonites[*] *giganteus*, Sow.
„ *Boloniensis*, De Lor.
„ *biplex*, Sow.
Ammonites pseudo-gigas, Blake.
„ *triplex*, Morris.
„ *triplicatus*, Sow.

GASTEROPODA.

Buccinum naticoides, Sow.
„ *angulatum*, Sow.
Cerithium Portlandicum, Sow.
„ *concavum*, Sow.
Neritoma sinuosa, Morris.
Natica elegans, Sow.
Pleurotomaria rugata, Benett.
Buccinum angulatum, Sow. (*Pteroceras Oceani*), Brong.
Turbo apertus, Blake.

CONCHIFERA.

Astarte rugosa, Sow.
Corbula saltans, Blake.
Cyprina elongata, Blake.
Corbicella Portlandica, Damon.
Cardium dissimile, Sow.
Lucina Portlandica, Sow.

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upper beds contain the same species as on this side of the English Channel. Some of the second-rate streets, I observed, were paved with Portland Stone, containing numerous casts of *Trigonia gibbosa*, *Cerithium Portlandicum*, &c.

[*] All the large Ammonites in the Isle of Portland are usually referred to *Am. giganteus*, Sow. There are, however, other large species found in the Continental Portland Beds. M. de Loriol has separated from *Am. giganteus*, under the name of *Am. Boloniensis*, those specimens which have on the back of the whorls twice as many ribs as on the lower half of the whorl, while Mr. Blake has made a new species of those specimens which have on the inner half of the whorl large knobby ribs, which bi- and trifurcate—viz. *Ammonites pseudo-gigas*. Blake ('Quart. Journ. Geol. Soc.,' vol. xxxvi.)

Lucina plebeia, Cont.
Lithodomus Portlandicus, Damon.
Lima Rustica, Sow.
„ *Coodei*, Damon.
Modiola pallida, Sow.
Mytilus.
Ostrea expansa, Sow.
„ *multiformis*, K. & D.
Pleromya tellina, Ag.
Perna mytiloides, Lam.
Plicatula echinoides, Blake.
Pecten lamellosus, Sow.
„ smaller sp.
Sowerbia Dukei, Damon.
Trigonia Damoniana, Lor.
„ *densinoda*, Etheridge.
„ *gibbosa*, Sow.
„ *incurva*, Sow.
„ *Manseli*, Lyc.
„ *muricata*, Goldf.
„ *tenuitexta*, Lyc.
Unicardium circulare, D'Orb.

BRACHIOPODA.

Waldheimia Boloniensis, Rigaux.

ANNELIDA.

Serpula gordialis, Schl.
Serpula triserrata, Sow.

CORALS.

Isastræa oblonga, Fleming.

Though the marine beds above and below the Portland Rock are distinguished by an abundance of Ammonites, only three species are referred to the Portland Series; but, as remarked by Sir R. Murchison, this paucity of species is compensated for by the frequent occurrence of the same species, and by the extraordinary size of the individuals.

The annual production from the whole of the quarries in the Island was, in the year 1839, reported at 24,000 tons, equal to an area of one acre of good stone; the entire area remaining unworked being estimated at 2000 acres. In 1855 the quantity of stone conveyed on the Portland Railway was,

Block	22,995	tons
Roach	3,547	„

besides that which was shipped from other parts of the Island. In the following years the quantity of stone which passed over the Portland Quarries Railway was as follows:—

1840	21,207
1850	25,433
1861	55,143
1865	81,649
1868	68,075
1870	53,394
1875	56,841
1880	48,912
1881	55,387
1882	45,967

The amount exported without passing over the railway is computed to have been from 5000 to 10,000 tons annually. The above calculation is exclusive of stone quarried by the convicts from the Crown Quarries for various Government works, and of the enormous consumption during the construction of the Breakwater, commenced in the year 1847 and completed in 1862.

The quality and durability of the Portland Stone, like those of other oolitic limestones, depend very much on the nature of the cementing matter by which the oviform particles are held together. The hardest beds have their cementing matter in a solid and partially crystallized form. In the softer stone the cementing matter is in an earthy, friable, or powdery state; hence, on exposure to the effects of the atmosphere, it more readily suffers decomposition than does the former.

An interesting account of the stone-quarries of Portland is given by Smeaton, who visited them previous to the building of the Eddystone Lighthouse. This narrative, though written a century ago, is in most particulars applicable to the present time. The mode of working the stone appears to have undergone no change. The tools and appliances made use of (with the exception of a modern crane) remain the same.

Report with Reference to the Selection of Stone for Building the new Houses of Parliament. Presented March 1839.

St. Paul's Cathedral, London. Finished about 1700. Built of Portland Oolite from the Grove Quarries on the east cliff. The building generally in good condition, especially the north and east fronts. The carvings of flowers, fruits, and other ornaments, are throughout nearly as perfect as when first executed, although much blackened. On the south and west fronts larger portions of the stone may be observed of their natural colour than on the north and east fronts, occasioned by a very slight decomposition of the surface. The stone in the drum of the dome and in the cupola above appears not to have been so well selected as the rest; nevertheless, scarcely any appreciable decay has taken place in those parts.

PORTLAND. *New Church*, built 1776. Portland Oolite. Fine Roach. In a perfect state of preservation, exhibiting the original tool-marks.

Old Church. In ruins, near Bow and Arrow Castle (15th Century); of Portland Oolite, resembling Top Bed; in very good condition; original tool-marks still appear in the north front.

Bow and Arrow Castle. Many centuries old; of Portland Oolite. The ashlar resembles the Top Bed, and is in perfect condition; the quoins and corbels of the machicolated parapet appear to be of the Cap Bed of Portland Oolite, and are in good condition.

Wyke Church (15th Century). Of Oolite similar to Portland; the whole in good condition, except the mullions, tracery, and dressings of doors and windows, which are constructed of a soft material, and are all decomposed. On the south side the ashlar is in part covered with rough cast. The entire building is thickly covered with lichen.

Sandsfoot Castle, near Weymouth, constructed of Portland Oolite in the time of Henry VIII., is an example of that material in excellent condition; a few decomposed stones used in the interior, and which are exceptions to this fact, being from another Oolite in the immediate vicinity of the castle.

The Report from which the above extracts are taken states that buildings situated in the country possess a great advantage over those in populous and smoky towns, owing to lichens with which they are covered in such situations, and which seem to exercise a protective influence against the ordinary causes of the decomposition of the stone upon which they grow. As an instance of the difference of degree of durability in the same material, according as it is exposed to the effects of the atmosphere in town or country, the report calls attention to the several frustra of columns, and other blocks of stone, which were quarried at the time of the erection of St. Paul's Cathedral, and are now lying in the Island of Portland, near the quarries from whence they were obtained. These blocks are covered with lichens, and though they have been exposed to all the vicissitudes of a marine atmosphere for more than 180 years, they still exhibit, beneath their lichen, their original form, even to the marks of the chisel employed upon them; while the stone which was taken from the same quarries and placed in the cathedral itself, is, in those parts which are exposed to the south and south-west winds, found in many instances to be fast mouldering away.

Sections of Quarries in Portland.

Section of *Grove Quarry, Red Croft.*

	feet.	ins.
Rubble	7	8
Dirt-bed	1	0
Roach	1	6
Top Bed	4	0
Middle or Curf Bed	5	6
Bottom Bed	7	0
Layer of dark flint separating the two beds of good stone.		

Waycroft Quarries.

	feet.	ins.
Rubble, &c.	8	0
Dirt-bed	1	0
Top Cap	4	6
Skull Cap	2	6
Roach	3	0
Top Bed	7	5
Loose stone and flint	7	0
Shelly stone	2	0
Bottom Bed	5	6

From the Top Bed of this quarry, Goldsmiths' Hall and the Reform Club House, in London, were built.

Maggot Quarry.

	feet.	ins.
Rubble, &c.	8	0
Dirt-bed	1	0
Cap	7	0
Skull Cap	2	0
Roach	2	6
Top Bed	8	6
Loose stone and flint	7	0
Bottom Bed	7	0

Goslin's Quarry.

	feet.	inches.
Rubble, &c.	8	0
Dirt-bed	1	0
Top Cap	6	0
Skull Cap	2	0
Roach	4	0
Top Bed	8	0
Rubbish Bed with layers of flint.		
Bottom Bed, very soft.		

The Portland beds at Upwey include the following species:—

Pycnodus pagoda, Blake.
„ *Bucklandi.*
Ammonites giganteus.
„ *Boloniensis.*
Pleurotomaria rugata.
Buccinum naticoides.
Cardium dissimile.
Pecten lamellosus.
Myacites Jurassii.
Trigonia gibbosa.
„ *incurva.*

A thin seam of clay, termed by the quarrymen "scum," containing no organic remains, is of interest as separating the Marine (Portland Stone) from the Freshwater (Purbeck formation). This slight deposit, spread over the whole of the top of the Portland Series, is the first indication of the emergence of the Portland Beds from beneath the sea.

These layers of clay or "dirt" characterise the Purbeck strata; and here, as well as at Ridgway, Lulworth, and Durlston Bay, they generally alternate with the beds of limestone. At Ridgway, however, this particular layer is absent, and the Portland and Purbeck series unite in a layer of hard stone, less than a foot in thickness, which sometimes presents the remarkable condition of a solid stratum, the upper part of which is of Freshwater, the lower of Marine origin.* With this sudden break from Marine to Freshwater there is no intermingling of fossils.

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* At Chicksgrove, S. Wilts, the junction of the Portland and Purbeck Formations is also without the intervention of clay or dirt, as shown by a specimen from Wockley, near Tisbury, amongst the rock specimens in the Museum of Practical Geology.

List of Fossils of the Portland Series of England.*

NOTE.—Names or Stars enclosed in brackets indicate that the occurrence has been previously recorded, but has not been verified.	Base at Tisbury. V.	Shotover and glauconitic sands. IV.	Swindon sands and clays. III.	Lower sands of the coast. II.	Upper sands of the coast. I.	Rubble-beds of Bucks and Oxon. 8.	Creamy limestone of Bucks and Oxon. 7.	*Trigonia*-beds of Swindon. 6.	Freestone at Tisbury and Swindon. 5.	Upper beds at Swindon and Tisbury. 4.	Chalky series at Chicksgrove. 3.	Flinty series of coast. 2.	Building-stone of Portland. 1.
Belemnites, sp.	..	..	..	..	..	..	*						
—— **Souichii,** *D'Orb.* ..	..	..	..	*									
Ammonites giganteus, *Sow.*	..	..	..	..	..	..	..	..	..	..	..	..	*
—— **pseudogigas,** *Blake*	..	*	..	..	..	*	*	..	..	..	..	*	
—— **boloniensis,** *De Lor.*	..	*	..	..	*	*	*	*	*	..	..	*	
—— **triplicatus,** *Sow.* ..	..	..	..	..	[*]	*	*	..	[*]	..	..	*	
—— **biplex,** *Sow*	..	*	*	*	*	*	..	..	*	..	..	[*]	
—— **pectinatus,** *Ph.* ..	..	..	*	..	..	*	..	*					
—— **Bleicheri(?),** *De Lor.*	..	..	..	..	..	..	..	*					
—— **Boisdini,** *De Lor.* ..	..	..	..	..	*?	..	..	*	..	..	..	*	
Alaria Beaugrandi, *De Lor.*	..	..	..	..	..	..	*						
—— **(*cf.* Thurmanni,** *Cont.*)	..	..	..										
Buccinum naticoides, *Sow.*	..	..	..	..	..	..	[*]	..	..	..	..	..	*
—— **angulatum,** *Sow.* ..	..	..	..	..	..	..	..	..	..	*	..	..	*
Natica elegans, *Sow* ..	..	..	..	..	..	[*]	*	*	..	..	..	*	*
—— **elegans,** *De Lor.* non *Sow.*	..	..	..	..	..	..	..	*					
—— **ceres,** *De Lor.* ..	..	..	..	..	..	..	*						
—— **incisa,** *Blake*	..	..	..	*	..	..	*						
—— **turbiniformis,** *Rom.*	..	..	..	..	..	*							
[—— **Marcousana,** *D'Orb*]	..	..	..	..	..	..	*						
[—— **Hebertana,** *D'Orb.*]	..	..	..	..	..	..	*						
Pseudomelania (*cf.* multispirata, *Et.*) ..	..	..	..	..	..	..	..	..	..	..	..	*	*
Cerithium portlandicum, *Sow.*	..	..	..	..	..	[*]	*	..	..	*	..	..	
—— **concavum,** *Sow.* ..	..	..	..	..	..	..	..	..	..	*			

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* Taken by the author's permission from the Rev. J. F. Blake's paper "On the Portland Rocks of England." Quart. Journ. Geol. Soc., vol. xxxvi. pp. 225–227, 1880.

LIST OF FOSSILS—*continued.*

NOTE.—Names or Stars enclosed in brackets indicate that the occurrence has been previously recorded, but has not been verified.	Base at Tisbury. V.	Shotover and glauconitic sands. IV.	Swindon sands and clays. III.	Lower sands of the coast. II.	Upper sands of the coast. I.	Rubble-beds of Bucks and Oxon. 8.	Creamy limestone of Bucks and Oxon. 7.	*Trigonia*-beds of Swindon. 6.	Freestone at Tisbury and Swindon. 5.	Upper beds at Swindon and Tisbury. 4.	Chalky series at Chicksgrove. 3.	Flinty series of coast. 2.	Building-stone of Portland. 1.
Cerithium Bouchardianum, *De Lor.* ..	..	..	..	..	..	..	..	..	..	*			
—— Boisdini, *De Lor.* ..	..	..	..	..	..	..	..	..	..	..	..	*	
—— trinodule, *Buv.* ..	..	..	..	..	..	..	..	..	..	..	..	*	
—— bifurcatum, *Blake* ..	..	..	*										
—— Hudlestoni, *Blake* ..	..	..	..	..	..	..	*						
Turritella minuta, *Koch & Dunk*	..	..	..	..	..	..	..	..	..	*			
Turbo Foucardi, *Cott.* ..	..	..	*										
—— apertus, *Blake* ..	..	..	..	..	..	..	..	..	..	..	..	..	*
Delphinula globosa, *Buv.*	..	..	*										
[Littorina paucisulcata, *Ph.*	..	[*?]											
Neritoma sinuosa, *Morris*	..	..	..	..	..	..	[*]	..	..	*	..	..	*?
Nerita minor, *De Lor.* ..	..	..	..	..	..	..	..	..	..	*			
Trochus permedius, *De Lor.*	..	..	..	..	..	..	..	..	..	*			
Pleurotomaria rugata, *Ben.*	..	..	*	..	..	*	*	*	..	..	..	*	
—— Rozeti, *De Lor.* ..	..	..	..	..	..	..	..	..	..	..	..	*	
Rissoa acuticarina, *Blake*	..	..	..	..	..	..	*						
Pleuromya tellina, *Ag.* ..	..	..	..	*	..	*	*	*	*	..	*	*	
—— Voltzii, *Ag.*	..	*	*	..	..	..	*						
——, sp.	*												
Plectomya rugosa, *Röm.*	..	..	*	..	*								
Pholadomya tumida, *Ag.*	..	[*]	*										
Thracia tenera, *Ag.* ..	..	..	..	*	*	*	..	*					
Neæra portlandica (?), *Cott.*	..	..	..	..	..	..	*	..	..	*			
Corbula saltans, *Blake* ..	..	..	*[1]	..	..	..	*	..	*	..	..	*	*

LIST OF FOSSILS—*continued.*

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	V.	IV.	III.	II.	I.	8.	7.	6.	5.	4.	3.	2.	1.
Sowerbya Dukei, *Damon*	..	..	..	..	..	..	..	..	..	..	..	..	*
—— longior, *Blake* ..	..	..	*	..	..	*							
Myoconcha portlandica, *Blake*	..	..	*	..	..	*							
—— Sæmanni, *Dollf.* ..	..	..	*										
Cypricardia costifera, *Blake*	..	..	..	..	..	..	*	*					
Anisocardia pulchella, *De Lor.*	..	..	..	..	..	..	*	*					
Isocardia autissiodorensis *Cott.*	..	..	..	*	*								
Astarte rugosa, *Sow.* ..	..	..	..	..	..	[*]	*	..	..	*	..	[*]	
—— Sæmanni, *De Lor.*	..	..	*										
—— polymorpha, *Cont.* ..	..	..	*										
—— supracorallina, *D'Orb.*	*?												
[—— ovata, *Sow.*]	..	..	..	..	..	[*]							
Cyprina elongata, *Blake*	..	..	*[1]	..	*	..	*	*	..	..	..	*	
—— swindonensis, *Blake*	..	..	*	..	..	..	..	*?					
—— implicata, *De Lor.* ..	..	..	..	*	*	*	*						
—— pulchella, *De Lor.* ..	..	..	*	..	..	..	..	*	*				
—— Brongniarti, *Pict. et R.*	..	..	..	..	..	*							
Unicardium circulare, *D'Orb.*	..	..	..	..	..	*	..	..	..	..	..	[*]	
Corbicella portlandica, *Damon*	..	..	..	..	..	..	..	..	..	..	..	[*]?	
—— Moræana, *Buv.* ..	..	..	..	..	..	..	..	..	..	*			
Lucina portlandica, *Sow.*	..	..	..	..	..	..	*	..	..	*			
—— plebeia, *Cont.* ..	..	..	..	..	..	..	..	*	..	..	*	*	*

List of Fossils—*continued.*

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	V.	IV.	III.	II.	I.	8.	7.	6.	5.	4.	3.	2.	1.
Lucina fragosa, *De Lor.*	..	..	*										
—— minuscula, *Blake* ?	..	..	..	..	..	..	*						
Cardium dissimile, *Sow.*	..	..	..	..	[*]	*	*	*	..	*	*	*	
—— Pellati, *De Lor.* ..	..	*	..	..	..	*	..	*					
—— ? calcareum, *Blake*	..	..	..	..	*	..	*	..	..	..	*		
—— Morinicum, *De Lor.*	..	..	*										
Trigonia gibbosa, *Sow.* ..	..	..	..	..	..	?	*	*	*	*	*	*	*
—— tenuitexta, *Lyc.* ? ..	..	..	..	..	..	..	*						
—— Manseli, *Lyc.* ..	..	..	..	..	..	*							
—— incurva, *Benett* ..	..	..	*?	*	*	*	*	*	..	..	..	*	
—— radiata, *Benett* ..	*												
—— Pellati, *De Lor.* ..	*	*	*	*	*	*	*						
—— Voltzii, *Ag.*	..	..	..	..	..	*	..	*					
—— muricata, *Goldf.* ..	..	..	..	*	*	*	..	*					
—— variegata, *Credner* ..	*												
—— Carrei, *De Lor.* ..	..	..	..	*?	..	*?	..	*					
—— concentrica, *Ag.* ..	*												
—— Micheloti, *DeLor.* ..	*?	..	..	..	..	*							
—— cymba, *Cont.*	..	..	..	..	[*]								
—— swindonensis, *Blake*	..	*	*										
—— alina, *Cont.*	..	..	..	..	[*]								
Leda	..	..	..	..	..	..	..	..	..	*			
Nucula obliquata, *Blake*	..	..	..	..	..	..	*						
Arca Beaugrandi, *De Lor.*	..	..	*	..	..	..	*	*	..	*			
—— (*cf.* velledæ, *De Lor.*)	..	..	*	*									
Lithodomus portlandicus, *Damon*	..	..	..	..	..	..	..	..	..	..	..	*	
——, small sp.	..	..	*	..	..	..	*						
Modiola pallida, *Sow.* ..	..	..	..	..	..	..	*	..	..	..	..	[*]	

LIST OF FOSSILS—*continued.*

NOTE.—Names or Stars enclosed in brackets indicate that the occurrence has been previously recorded, but has not been verified.	Base at Tisbury. V.	Shotover and glauconitic sands. IV.	Swindon sands and clays. III.	Lower sands of the coast. II.	Upper sands of the coast. I.	Rubble-beds of Bucks and Oxon. 8.	Creamy limestone of Bucks and Oxon. 7.	*Trigonia*-beds of Swindon. 6.	Freestone at Tisbury and Swindon. 5.	Upper beds at Swindon and Tisbury. 4.	Chalky series at Chicksgrove. 3.	Flinty series of coast. 2.	Building-stone of Portland. 1.
[Modiola bipartita, *Sow.*]	..	..	..	..	..	..	[*]						
Mytilus jurensis, *Röm.* ..	*	..	..	..	..	*	[*]	*	*				
—— unguiculatus, *Ph.* ..	..	..	..	..	..	..	..	*	*				
—— autissiodorensis, *Cott.*	..	..	*	*	*	*	*?						
—— boloniensis, *De Lor.*	..	..	*	..	..	*	..	*	..	..	..	*	
—— longævus, *Cont.* ..	..	..	*										
—— Pinna suprajurensis, *D'Orb.*	..	[*]	*										
Perna "mytiloides" ..	..	..	..	..	..	..	*	..	*	*	..	*	*
—— Bouchardi, *Oph.* ..	*	..	*	..	..	*	*	*					
—— ? Bayani, *De Lor.* ..	..	..	*										
—— Avicula octavia, *D'Orb.*	..	..	..	*									
Plicatula Boisdini, *De Lor.*	..	..	..	..	..	*							
—— echinoides, *Blake* ..	..	..	..	..	..	*	*	..	..	..	..	*	
Lima rustica, *Sow.*	..	..	..	..	[*]	*	*	*	*	..	..	*	
—— boloniensis, *De Lor.*	..	..	*	*									
—— ornata, *Buv.*	..	..	..	..	..	*	..	*					
—— bifurcata, *Blake* ..	..	..	..	..	..	*							
Pecten lamellosus, *Sow.* ..	..	[*]	..	..	*	*	*	*	..	*	*	*	*
—— suprajurensis, *D'Orb.*	..	..	*	..	..	..	*	..	..	..	..	*	
—— Morini, *De Lor.* ..	..	..	*	*	*								
—— solidus, *Röm.*	..	[*]	*	..	*	..	..	..	..	..	..	*	
—— concentricus, *K. & D.*	*?												
Placunopsis Lycetti, *De Lor.*	..	..	*										
Ostrea expansa, *Sow.* ..	..	..	..	..	..	..	*	..	..	..	*	[*]	
—— bononiæ, *De Lor.* ..	..	..	*	..	..	..	*						
—— multiformis, *K. & D.*	..	..	*	..	..	..	..	..	..	..	..	*	

List of Fossils—*continued.*

Note.—Names or Stars enclosed in brackets indicate that the occurrence has been previously recorded, but has not been verified.	Base at Tisbury.	Shotover and glauconitic sands.	Swindon sands and clays.	Lower sands of the coast.	Upper sands of the coast.	Rubble-beds of Bucks and Oxon.	Creamy limestone of Bucks and Oxon.	*Trigonia*-beds of Swindon.	Freestone at Tisbury and Swindon.	Upper beds at Swindon and Tisbury.	Chalky series at Chicksgrove.	Flinty series of coast.	Building-stone of Portland.
	V.	IV.	III.	II.	I.	8.	7.	6.	5.	4.	3.	2.	1.
Ostrea solitaria, *Sow.* ..	..	..	..	*	*	*	*	..	*	..	..	[*]	
[Gryphæa dilatata, *Sow.*]	..	[*]											
Exogyra bruntrutana, *Thurm.*	*	..	*	..	*	..	*						
[—— Spiralis, *Goldf.* ..	..	..	..	..	..	..	[*]						
Waldheimia boloniensis, *Rigaux*	..	..	..	..	..	..	..	..	..	..	..	..	*
Rhynchonella portlandica, *Blake*	..	..	..	*									
Discina Humphresiana, *Dav.*	..	..	..	*									
Lingula ovalis, *Sow.* ..	..	..	..	*									
Serpula gordialis, *Schl.* ..	..	..	..	..	..	..	*	..	..	..	..	*	
—— quinquangularis, *Goldf.*	..	[*]	..	..	..	*	*						
Glyphea, sp.	..	..	..	..	..	*							
Echinobrissus Brodiei, *Wr.*	..	..	..	..	..	..	*	*					
Acrosalenia Kœnigi, *Desm.*	..	*	*										
—— brillensis, *Wr.* ..	..	..	..	..	..	..	[*]						
Isastræa oblonga, *Flem.*	..	..	..	..	..	..	..	..	*	..	..	*	
Chimæra Townsendi, *Ag.*	..	..	..	..	..	[*]?	..	..	..	..	..	*	
Pycnodus Bucklandi, *Ag.*	..	..	..	..	..	..	..	..	..	..	..	*	
—— pagoda, *Blake* ..	..	..	..	..	..	..	..	..	..	..	..	*	
Chelone ?	..	..	..	..	..	..	..	..	..	..	..	*	
Steneosaurus gracilis, *Ph.*	..	[*]											
Ceteosaurus longus, *Owen*	..	..	..	..	..	[*]							
Goniopholis	..	..	..	..	..	..	..	..	..	*			

PORTISHAM.

On the summit of the hill overlooking the village of Portisham, and one mile east of the "Hardy Monument," a quarry has been opened to furnish stone for the bridges of the Abbotsbury Railway; the following section is here exposed, the beds dipping north :—

No. 1.	Top bed of weathered, thin Purbecks	2 feet.
2.	Soft porous beds with *Cyclades* in abundance	4 "
3.	Thin limestone with layers of clay in succession .. .. In the middle of which is a dark clay which may be an equivalent to the "Dirt Bed," and is about 2 ft. 4 in. in thickness.	20 "
4.	Freestone, with vertical cracks	7 "
5.	Similar stone, but a good deal broken, and towards the bottom much decayed	6 "

The beds dip to the north. No. 4 is the best bed, though inferior to the Portland Base bed, Island of Portland, and differs also from that of Ridgway. There is no "Cap" or "roach" and the whole Portland Series is destitute of fossils.

At some distance below the base of the quarry, the Portland Sand crops out, but none of the intermediate beds. Further working of this district may present some deviations from the above section, but the Portland Beds, as remarked by Buckland and De la Beche, suddenly terminate at Portisham (p. 19).

PURBECK FORMATION.*

SKULL CAP.

BED 11.†—The term "skull cap," applied to the solid layers constituting the lowest bed of the Purbeck formation, is intended to denote its position in relation to other beds below. It is a hard cream-coloured limestone of irregular texture, full of minute cavities lined with crystallised carbonate of lime, of very variable thickness, and with an undulating or lenticular form. In some places it is not more than a foot thick, but sometimes it suddenly swells in a short horizontal distance to a thickness of two and even three feet.

This complete covering of the Portland Oolite with a freshwater deposit, corresponds to what may be seen at the base of the Purbeck Series at Ridgway, Lulworth Cove, Durlston Bay, &c.

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* A more detailed account of the Purbeck Strata will be found in a future chapter.

† See Fig. 34, p. 81.

BED 10.—LOWER DIRT-BED, or "Dirt below the Cap," as separated by the Cap Stone from the upper or great dirt-bed. Cycadeæ, of the same species as those from the upper dirt-bed, though found in this deposit, generally penetrating into the solid stone above, are of not unfrequent occurrence. No fossil trees are met with in this lower dirt-bed, though Dr. Fitton* relies upon a prostrate trunk having been taken from the "dirt" below the cap, in his description of a section of the Portland beds exposed on the west side of the road leading from Upton to Poxwell. The deposit bears more of a clayey than an earthy character, and never, as far as I could detect, contains any portions of carbonaceous matter, such as characterise the upper or great dirt-bed.

BED 9.—Cap, or Top Cap, a calcareous slate, the thickest bed of all the Purbeck series;† it is white, hard, and of irregular structure. Neither this nor the Skull Cap has an oolitic structure like the Portland Stone, but is of a closer and flinty texture, a quality which prevents its being easily worked; partly for which reason, and partly on account of the abundance of other stone, this bed is neglected. The upper portion, which separates from the main bed, and is called the "upper rising," is of unequal thickness. Its surface is more or less coated with stalagmite, and for about 18 inches it readily splits into slabs. Towards the base it assumes a porous structure, traversed with sinuous cavities or perforations, perpendicular to the surface of the stratum.‡ Other cavities are filled with globules of carbonate of lime.§ The Top Cap contains bones and teeth of Fishes, and occasionally entire specimens. Cyclas, though so abundant in the corresponding bed at Ridgway and Lulworth, are here sparely distributed.

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* 'Trans. Geol. Soc.,' ser. 2, vol. iv. p. 222.

† At Mewps Bay the corresponding bed is 8 feet in thickness, and is overlain by the dirt-bed with Cycadeæ.

‡ This form of deposit in its most porous state is known as "Calcareous Tufa;" when in a more solid form it is called "Travertin," the "Travertino" of Italy, the limestone of which the Coliseum and many other ancient works in Rome are constructed.

§ These cavities in freshwater limestone are considered by M. Beudant as having been caused by the disengagement of gas. 'Trans. Geol. Soc.,' GREAT DIRT-BED. BED 8.—Mr. Webster ('Trans. Geol. Soc., vol. ii. part 1) was the first to point out the singular character of the earthy deposit known as the "*Dirt-Bed.*" It had been previously supposed that the fossil trees (Cycadeæ, Coniferæ, &c.) were from the oolite itself, whereas the Dirt-Bed is the actual soil in which they grew and in which their remains occur. This soil, which nourished the roots of an ancient forest, is a bed of about a foot in thickness, of a dark-brown colour, not black, as generally described, but containing patches of a jet-black substance like soot, which appears to have been deposited at a later time. The great interest attaching to the Portland Dirt-Bed is not in consequence of the mere accumulation itself, as similar deposits must necessarily have occurred at every geological period, but from the fact of its preservation, and that between beds of stone, as the change of condition consequent upon the transition from one kind of deposit to another might be expected to disperse such an earthy material.

Dr. Hugo W. Müller, F.R.S., has favoured me with the following complete analysis of an average sample of the Purbeck 'Dirt-Bed' from the Isle of Portland :—

COMPOSITION OF THE PORTLAND DIRT-BED.

	per cent.
Moisture (in the air-dry soil)	3·38
Organic Matter (inclusive of 0·05 Nitrogen)	2·56
Oxide of Iron Alumina	2·45
Lime	34·07
Magnesia	0·53
Potash	0·63
Soda	0·42
Silica	0·79
Sulphuric Acid	0·15
Phosphoric Acid	0·14
Carbonic Acid and loss	28·88
Silica and Insoluble Silicates	26·00
Total	100·00

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vol. ii. p. 83), but, this having been formed at the bottom of a fresh-water lake, dry land was near, and therefore drifted branches and other portions of trees might have been imbedded, and, decaying after the partial consolidation of the sediment, might have left these spaces.

COMPOSITION OF THE 26·0 PER CENT. OF INSOLUBLE SILICATES AND SILICA.

Oxide of Iron and Alumina	5·84
Silica	19·05
Lime	0·10
Magnesia	0·36
Potash	0·45
Soda	0·20
Total	26·00

On which results Dr. Müller further remarks upon the large admixture of stony fragments, principally composed of carbonate of lime, and about 26 per cent. of an argillaceous quartz-sand:—

"All the nodules seem a little rolled, and whilst some are calcareous, there are others which remind one of *Greensand.* Now on taking the fine earthy part from which these nodules have been separated, it was found that *it contains as much as* 44·10 *per cent. insoluble matter*, whilst the original sample (taken as a whole) *contains only* 28·56 per cent., and of course the percentage of all the other constituents is altered in a like manner if the nodules are taken out.

"Under these circumstances I think that the Dirt-bed must be considered to contain these nodules as a normal constituent, and in giving its chemical composition, a separation of them is inadmissible."

The Tchornozem, or "Black Earth," of Central Russia, somewhat resembles the Dirt-bed of the Purbecks, if the supposition of its terrestrial origin is correct, viz.: that the former is derived from the decomposed débris of an ancient forest. This opinion prevails in Russia, but Sir R. Murchison considered it as pulverised Jurassic Shale, and hence formed under water. ('Geology of Russia,' vol. i. p. 560.) The like view was held by the late Hon. J. H. Fox-Strangways, who, in addition to his qualifications as a Botanist, possessed considerable knowledge of the country, and he says "that the character of the Black-earth being everywhere the same, it is difficult to imagine that the same plants grew in so many situations, with opposite aspects, and over so vast a surface as is covered by this deposit." ('Trans. Geol. Soc.,' vol. v.)

Whatever may be its source, it contains elements of fertility which produces the richest soil in Russia, both for corn and grass.

With the view of testing the relative growing properties of both soils, I brought from Central Russia, in the summer of 1883, samples of the Tchornozem from the two Governments of Charkoff and Kief. In these, and in the Portland Dirt-bed and in common garden-mould, I sowed mustard-and-cress seed, with the following result:—

No. 1. Tchornozem from Charkoff; No. 2. Tchornozem from Kief, gave first appearance of growth, but in fulness of crop Nos. 1 and 2 were about equal, any difference being in favour of No. 1.
3. Garden-mould. Slower in growth and smaller crop.
4. "Dirt-bed" of the Purbecks. Weakest, both in growth and crop.

The experiment was repeated with Parsley, and with like results.

The results of the comparative fertility of the Tchornozem, garden-mould, and Dirt-bed, may find an explanation in the very large percentage of *available* Nitrogen contained in the Tchornozem, which, on the other hand, is almost nil in the Dirt-bed.

Besides the elements of fertility, the Tchornozem is, from the large proportion of Silica, a pulverised soil through which the roots and upward growth easily penetrate.

For the following Analysis of this remarkable deposit I am indebted to Dr. Augustus Voelcker, Dec. 10th, 1883:—

Composition of a Sample of Black Russian Wheat-Soil from the Village of Ternachera, Government Samara, Russia.

Soil dried at 212° F.	per cent.
Organic Matter and Water of combination*	10·095
Oxide of Iron (ferrous oxide)	5·052
Alumina	3·901
Lime	3·553
Magnesia	1·154
Potash	·922
Soda	·181
Sulphuric Acid	·071
Nitric Acid	·002
Chlorine	·009
Phosphoric Acid	·201
Silica and Insoluble Silicates (insol. in Hydrochloric Acid)	73·201
Carbonic Acid and loss	1·658
	100·000

* Containing Nitrogen ·362, equal to Ammonia ·437.

COMPOSITION OF THE "SILICA AND INSOLUBLE SILICATES" (73·20).

	per cent.
Oxide of Iron	2·41
Alumina	6·66
Lime	·85
Magnesia	·98
Potash	1·26
Soda	·52
Silica and loss	60·52

Extent and Range.—Besides the Isle of Portland, the Dirt-Bed occurs in the cliff east of Lulworth Cove. At Ridgway it is less distinctly represented, and is separated from the "Cap" by a layer of soft chalk-like stone. Beyond this district it is found at Swindon * in Wilts, at Thame in Oxfordshire, and in Buckinghamshire. Out of England it has hitherto only been observed on the coast near Boulogne; but in none of these places is it so well developed as in the Isle of Portland, where the fossil trees and plants are not only found upright in the spots on which they flourished, but even the soil in which they grew still retains much of its primitive character.

FOSSILS OF THE DIRT-BED:—CYCADEÆ.

These singular vegetable productions, so abundant in the Dirt-Bed of the Isle of Portland, are better known as fossil "crow's-nests" to the quarrymen, who regard them as the nests dislodged from the petrified trees with which they are associated. Sir J. Smith, in describing a recent Cycas, which bore fruit at Farnham in 1799, makes the same comparison. These fossil plants are allied to the existing family of *Cycadeæ*, and belong to two genera, viz. *Cycas* and *Zamia*. Five species are recorded of the first genus, and of the second, seventeen. From their resemblance to this group, Dr. Buckland proposes the name *Cycadeoideæ*;* M. Blainville has assigned them to a genus termed *Mantellia;* Mr. Brown, from the result of a comparison with the living Cycas and Zamia † considers that until sufficient reasons are given for separating them from these genera, the general term *Cycadites* is more appropriate.

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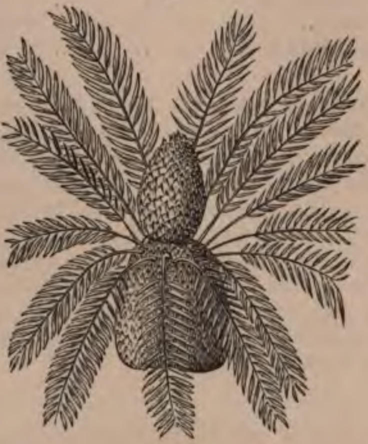
* At Swindon (Parish Quarry), the Dirt-bed is not horizontal and of uniform thickness, as at Portland, but occupies a basin-shaped cavity which towards the centre is from 3 feet to 4 feet in thickness, of variegated colour, with numerous specks of carbonaceous matter, and in places it constitutes larger deposits in the form of a dark-brown powder. In another quarry, portions of trees in an erect position were seen, as in the Isle of Portland, but were not of common occurrence.

Fig. 39.



Zamia pungens. (Living species.) Habitat, Cape of Good Hope.

A further re-distribution of genera has been proposed by Mr. Carruthers, who, while retaining the two genera *Mantellia* and *Bucklandia*, establishes four new genera, viz. *Yatesia*, *Williamsonia*, *Fittonia*, and *Benettites*.‡

Of the twenty-two species referred by this author to Great Britain, six species have been found in Dorsetshire.

Figures of both these species found in the Isle of Portland appear in Supplement, Plate 8, figs. 1 and 2. They vary in size from

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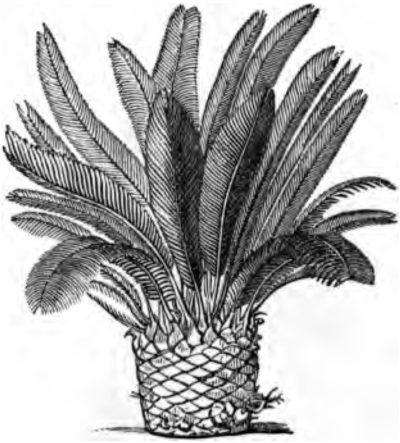
* Bridgewater Treatise, vol. i. p. 496, Note.

† *Zamia horrida*, or Hottentot Bread-fruit Plant, is one of the species.

‡ 'Trans. Linn. Soc.,' vol. xxvi. p. 675.

6 inches to 12 inches in height, and from 9 to 12 inches in diameter, and have a hollow concentric cavity at the top. The numerous scales surrounding the trunk (not usually so distinctly seen as in the specimen figured) form the bases of the leaf-stalks. As yet no leaves of the species under consideration have been discovered, though both stems and leaves of other Cycadeæ have been found both in the Great Oolite and Lias.

Fig. 40.



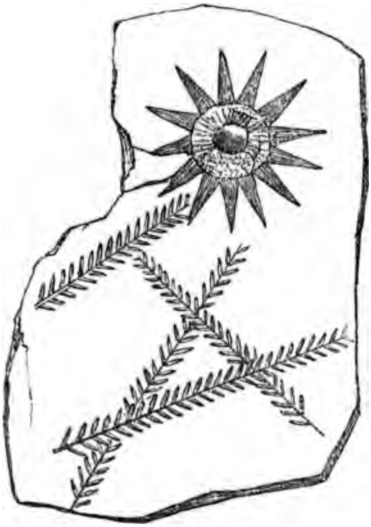
Cycas revoluta. (Living species.) Habitat, Tropics.

In the *Cycas revoluta* (fig. 40), from the scars or scales which protrude near the margin, spring the leaves, which, like those of the pine-apple, crown the summit of the plant, and correspond to the cavity which characterises the Portland Cycadeæ. As the living species of this family of plants inhabit India, New Holland, and the Cape of Good Hope, it may be supposed that the climate of this area was once of a temperature somewhat similar to that of those regions.

Fossil Trees.—Cycadeæ occur in both the upper and lower dirt-beds, but are scarce in the latter. Trees are found only in the upper or Great Dirt-bed. From the number and position of their remains they appear to have grown as close to each other as the trees of a modern forest. In White Street Quarries (Westons), I observed (April 1867) over a surface of a few yards, seven stumps of trees each 18 inches high, standing erect in their native soil; as were also two Cycadeæ.

The prostrate trunks lie near the stumps from which they had been severed. The latter, many of which are of great bulk, still stand erect in their original positions, and from their roots filling cavities in the underlying stone, the latter must have been in a soft state, ere the trees reached maturity. The fallen portions generally lie in the direction of the length of the Island, that is, nearly north and south. The petrifying and fossilizing matter of both trees and Cycadeæ is silica, for though surrounded with carbonate of lime above

Fig. 41.

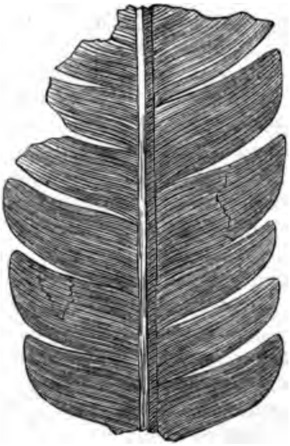


Pterophyllum (*Cycadites*) *pecten*. Oolite. Scarborough. (In " Leckenby Collection " of the Cambridge Museum.)

and below, they are composed almost entirely of silica.* Some specimens of the trees are covered with quartz crystals, and transverse sections exhibit the cellular cavities filled with siliceous matter. Dr. Prout, in a chemical analysis, found them to consist almost wholly of silica, with very slight traces of carbonate of lime and iron. Some of the darker parts contain a portion of bituminous matter. The concentric rings marking their annual growth are very distinctly preserved. The trees all belong to the family of *Coniferæ* (Pine family), trees that bear cones in which the seeds are contained, and, like the Cycadeæ, they require for their growth a higher tem-

Fig. 42.

From a Specimen in the Leckenby Collection.



Pterophyllum (*Cycadites*) *comptum*. Oolite. Scarborough.

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* MM. Cuvier and Brongniart, in their essay on the Geology of Paris (p. 56), state that the fresh water of the ancient world possessed properties which are not observed in that of our modern lakes: in the latter we find deposits of a friable kind only; but in the lakes of ancient date we have, in addition to other substances, flint, which has enveloped organic remains, converting the original structure into a silicious matrix, which surrounds them.

perature than is now prevailing in Great Britain. The existence of Pines and Cycadeous Plants, and the numerous minor forms of vegetation which once flourished in the Portland area of ancient days, is in striking contrast with the sterile character of the present surface of the Island, where (with the sole exception of the grounds around Pennsylvania Castle, and a few recently cultivated spots) scarcely a tree or shrub is to be seen.

The singular condition of the stone overlying the dirt-bed remains to be noticed. The latter is not more than a foot in thickness, while some of the trunks are three feet in length, and still retain their erect positions, whence it follows that their upper portions must either penetrate into the stone above (Soft Burr), or that the latter must have been deposited and consolidated over and around them.

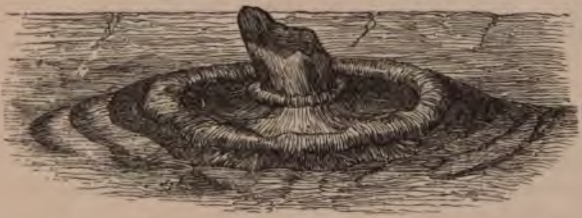
The presence of these upright portions is indicated by a rise or mound in the stratum of stone above. The circular ridges and depressions which surround some of the taller stumps, Professor Henslow conjectures to have been produced by the disturbance they would cause on the surface of the water, which was then so shallow that the waves were broken by them. This appearance is also seen in the "Fossil Forest," at Lulworth, where, on a kind of platform in the cliff, a little east of the Cove, the stony stratum immediately above the dirt-bed has enveloped the Cycadean stools, forming circular or dome-shaped masses of great size: in some instances the vegetable structure is preserved, in others a conical cavity is left, the stone having consolidated before the Cycadeæ perished. These formations are very numerous, and have a remarkable appearance. The familiar drawing of this site ('Trans. Geol. Soc.,' Ser. 2, vol. vi. p. 14, and repeated in so many geological works) is to some extent imaginary, as no erect stumps of trees in their native soil are now to be seen. The observer will here also notice some stools of an elliptical form with an inner depression, as if the stone had consolidated over a prostrate trunk which subsequently perished. Pebbles and larger fragments of stone, apparently derived from the beds beneath, are numerous in the dirt-beds; no organic remains

NOTE.—The petrified forest in the Suez Desert near Cairo will be familiar to many, consisting of the prostrate trunks of trees, some exceeding 60 feet in length, as completely silicified as are the Portland Coniferæ; but none of them can be traced to a given stratum, or to any vegetable soil, like those of Portland, as they lie scattered over the surface.

other than those mentioned have hitherto been discovered, though in Nova Scotia the only Reptilian remains ever found in the Coal Measures were discovered inside the trunks of fossil trees,* as were also the earliest known Pupa (pulmoniferous or air-breathing Molluscs). In the Purbeck Beds of Swanage both Mammalia and Pulmoniferous Molluscs occur.

BED 7. SOFT BURR.—This is the consolidated sediment which enveloped the Trees and Cycadeæ after their submergence in fresh water; the upright stumps of these penetrate the "Burr," causing the inequalities and swellings in the stone, represented in Fig. 43. Around the trunks, and between them and the "Burr," there is generally a small space filled with carbonaceous matter, the residuum of the outer portion of the tree. The Burr is a soft stone; "it stands fire," and is used for chimney-work and fire-places. It contains no fossils.

Fig. 43.



Drawing of the erect stump of a tree, protruding through the "Burr-stone" into the stratum above called the "Aish"; from Buckland and De la Beche, Memoir, p. 16.

BED 6. AISH.—Though associated with the "Burr," this bed, from its fissile or slaty character, is easily separated from it. The tops of the longer stumps of trees pass through the "Burr" into the "Aish:" the uneven surface of which often serves to indicate the presence of the trees beneath. It has been observed that the stone of both the "Aish" and the "Burr," when in contact with the trees, is harder and more flinty than is the case elsewhere.

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* 'On the Results of Recent Explorations of Erect Trees containing Animal Remains in the Coal-formation' of Nova Scotia; by J. W. Dawson. Phil. Trans., vol. clxxiii. p. 621 (1882).

12

BED 5.—"Clay," parting.

BED 4.—BACON TIER differs from the subjacent beds in its greater hardness, and in being deposited in bands which are sometimes separated by thin layers of sand. It contains no fossils. The seams of clay and carbonaceous matter repeated above and below the "Bacon Tier," and alternating with the solid beds, are of interest, as indicating the occurrence of a succession of changes over that area.

BED 3.—"CLAY" or "DIRT" seam.

BED 2. SLATE.—The deposit constituting the upper stratum of the Isle of Portland, though in some quarries 10 feet in thickness, varies in other parts of the Island from less than 3 feet to 15 feet. It is chiefly made up of a hard stone shivered into layers of about an inch thick. The whole bed is much shattered, and the stratification most irregular, particularly over a "gully," towards which the beds on either side incline sufficiently to determine the situation of one of those openings. This bed is without fossils, though *Cyprides* and *Cyclades* may be supposed to occur, as they are found in the neighbouring localities in nearly all the limestone beds of the Purbeck Series.

FISSURES.

Rents or "gullies" traverse the stony beds in a direction from north-east to south-west (Fig. 34). These fissures, which extend across the Island, vary in width from one foot to several feet, and are accompanied by minor cracks running in the same direction, which latter greatly facilitate the quarrying of the beds of marketable stone. The upper portions of the "gullies" are generally filled with rubbish formed of the coarser materials derived from the overlying beds, the slaty strata immediately above the chasms being either disjointed or highly inclined on both sides towards the gully (Fig. 34). In some places, large cavernous spaces communicate with the fissures, caused probably by the severance of masses of rock that have disappeared in the openings below. Similar fissures occur in this formation at Brill in Oxfordshire,* attended by a similar derangement of the overlying strata At Swindon they are filled with loose sand throughout, and are not open as in Portland.*

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* 'Geo. Trans.,' second series, vol iv. p. 255.

STALACTITE is formed by dropping water charged with calcareous matter in solution. All rain-water contains carbonic acid, which, when passing through strata containing lime, forms a soluble *bi-carbonate.* In dropping from the roofs of caverns, evaporation of the watery particles takes place, and the solid portion which remains behind forms stalactite pendants, which hang like icicles.† Their component parts are determined by the nature of the strata through which the water passes. At Portland they are composed of carbonate of lime, of an amber colour, the latter character being caused by the diffusion of oxide of iron. A beautifully crystallized form of calcareous spar, not uncommon, is composed of an aggregation of long slender translucent crystals, of a bright amber colour, and breaking with the rhomboidal fracture peculiar to crystallised carbonate of lime. Colourless crystals of the variety of calcite called *dogtooth-spar* are also found.

STALAGMITE.—When the water drops too quickly from the roof to allow of the formation of a stalactite, the deposit takes place on the floor on which it falls, and is then called stalagmite. In this latter form it is known by the Portland quarrymen as *sugar-candy, cauliflower*, &c. It is not uncommon to find stalactites that attain such a length as to become united with the stalagmite; and thus by the gradual accumulation of infiltrating matter, as in the manner here pointed out, the whole fissure or cavity becomes entirely filled with a solid mass of hard calcareous matter. The stalagmitic carbonate of lime, which has been deposited in this manner, and is quarried in some parts of Egypt in masses large enough for statuary purposes, is called *oriental alabaster*.

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* Fissures in rocks of volcanic origin are supposed to be occasioned by their contraction, while passing from a heated to a cool state. Their occurrence in stratified rocks may arise from the violent tension to which the solid strata would be subjected during its upheaval, or a tension that could only be relieved by a rent or fracture. In the latter instance, it is not uncommon to find the face of each side of the opening either polished or scratched from the rubbing together of the two sides. Another result is the horizontal displacement of the strata, i.e. a sinking or depression of the beds, on one side of the fracture, which sometimes amounts to several hundred feet. The continuity of the strata in the Portland fissures is but little interrupted.

† Such caves are met with in quarrying operations at Portland, but unhappily are not preserved. The celebrated cave of Adelsburg, near Trieste, with its ramifications, extends for several miles.

PURBECK FORMATION.

This formation was separated from the Wealden, and included in the Oolitic series, by the late Prof. Edward Forbes. It consists of limestones, shales, and sandstones, with clay-partings, and is divided into an *upper*, *middle*, and *lower* series, exhibiting alternations of fresh, brackish, or salt-water (marine) deposits, with soils formed on dry land. At the meeting of the British Association held in 1850, Professor E. Forbes communicated the results of his investigation 'On the succession of strata and distribution of organic remains in the Dorsetshire Purbecks.' The various localities at which his observations were made are Ridgway (near Upwey), Osmington, Lulworth Cove, Warbarrow Bay, Mewps Bay, and Durlston.*

For a study of the Dorsetshire Purbecks it is necessary to consult the "Memoir on the Purbeck strata of Dorsetshire," by the Rev. Osmond Fisher, M.A., F.G.S., in the Transactions of the Cambridge Philosophical Society, vol. ix.; and especially the "Sections, Vertical and Horizontal, of the Strata of the Isle of Purbeck," by H. W. Bristow, of the Geological Survey.

No fewer than nine distinct sections of the Purbeck strata are to be seen in and near Lulworth Cove. A steamer runs from Weymouth to this picturesque and favourite spot every Wednesday during the summer,† and from the latter place a boat should be taken to obtain a sea-view of the very interesting geological features displayed on this portion of the coast, where the Purbeck and the Chalk formations offer every degree of inclination, from the nearly horizontal to the vertical; while from their unequal degree of hardness, arches, caverns, peaks, and other singularly shaped rocks, have been produced, which have been already referred to and illustrated in the introductory chapter.

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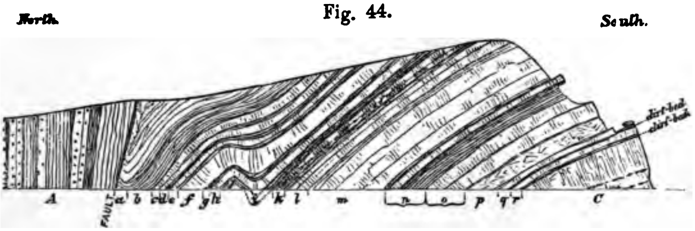
* The 'Purbecks' at Durlston Bay and the adjacent districts are described in the chapter relating to Swanage, p. 199.

† The distance from Weymouth to Lulworth across the bay is a little less than 10 miles. By road it is 16 miles. It may also be reached partly by rail, stopping either at Wool or Wareham Stations. From Wool to West Lulworth is 5 miles. From Wareham the distance is 8 miles; here, though not at Wool, a conveyance may be had.

NOTE.—Lulworth Castle is the residence of the Weld family, one of the most distinguished of the Roman Catholic families in England. After the French Revolution (August 1830) Charles X. and the exiled Royal family were received here, where they remained as guests until their removal to Holyrood Palace. The castle, built at the beginning of the 16th century, is considered to be a fine specimen of the architecture of that period. Between the years 1794 and 1817, Mr. Thomas Weld gave shelter and support to a colony of Trappist Monks. The Castle and grounds are thrown open to the public on Wednesdays. Bindon Abbey, an interesting ruin belonging to the same estate, is about a mile from Wool Station.

Fig. 44.



Section of the Coast on the East Side of Lulworth Cove.
By H. W. Bristow.

DESCENDING SECTION.

Chalk and Upper Greensand behind, forming the north side of the Cove, are not shown in the above Fig.

A. Hastings Sands and Weald Clay, forming vertical beds.

		ft.	in.
UPPER.	*a* PALUDINA CLAYS. Paludina Limestone. FISH - remains, *Pycnodus*	2	3
	b UPPER CYPRIS CLAYS AND SHALES	13	6
	c UNIO BEDS. Soft, green shale full of *Unio*. Bands of hard Limestone. "Beef," shelly Limestone and dark-grey Shales	7	9
	d BROKEN-SHELL LIMESTONE. Fish (teeth and palates), very numerous scales (*Pyncnodus*). Shells, *Paludina*, *Limnæa*, &c.	3	6
MIDDLE.	*e* CHIEF BEEF BEDS. Bands of dark, soft Clay, hard Shell-limestone, *Cyrena*. Beef with lines of perished shells ..	8	3
	f CORBULA BEDS. Hard Limestone, covered with fish-spines (*Asteracanthus*), 1 ft. 9 in. Shells, *Ostrea*, *Pecten*, *Cyrena*. Dark-grey Shales	15	0
	g SCOLLOP BEDS. Hard Shell-limestone	1	10
	h INTERMARINE BEDS. Dark Shales with lines of perished shells, 2 ft. 2 in. Bands of hard Limestone. Beef	7	6
	i CINDER BED.* Soft Cinder, 1 ft. 6 in. Hard Cinder, vast accumulation of *Ostrea distorta*	4	0
	k CHERTY FRESHWATER. Dark, sandy shales, 2 ft. Cream-white Limestone, with 3 distinct layers of black chert ..	5	9

* On the summit of this bed in Mewps Bay, Prof. Forbes discovered the first Echinoderm ever seen in the Purbeck series, *Hemicidaris Purbeckensis* (*H. Bouchardi* of continental authors); a genus characteristic of the Oolite period, and figured in Decades 3 to 5 of the Geological Survey. Mr. Bristow has since found spines and portions of the same species in the corresponding beds in the Vale of Wardour.

LOWER.	*l*	Marly Freshwater Beds. Bluish Shales with thin lines of Limestone, 2 ft. Towards the centre a band (2 ft. 6 in.) of pale-pink and variegated compact Limestone, rather abundant in scales, etc. of Fish, *Lepidotus;* Shells, *Hydrobia, Physa, Limnæa, Planorbis,* &c.	12	6
	m	Soft-cockle Beds. Hard and soft Marls occasionally hardening into beds of Limestone 7 ft. Pale-grey Limestone with shaly partings. Pseudomorphous crystals of Rock Salt, 3 ft. 6 in. Dark Shales and Limestone-bands, terminating with a slaty limestone and pale clay in alternating bands, lower part covered with small pebbles; 2 species of *Cypris,* and fish-remains; also pseudomorphous crystals of Rock Salt, 13 ft. Hard and soft Marls. Grey Shales and Limestone-bands. At bottom, hard Marl with cavities lined with flint and calcareous spar	39	0
	n	Hard-cockle Beds. At top hard fissile Limestone with thin layers of crystalline honeycombed Limestone, and a shaly parting, 4 ft. Yellow, sandy Limestone, very conspicuous from its colour, and mode of weathering; ripple-marks on under surface, 2 ft. Shelly Limestones, 6 ft. Dark sandy Shale, 2 ft.	14	0
	o	Cypris Freestone. Soft, slaty Limestone with *Cypris* and carbonaceous specks. Layers of pseudomorphous crystals of Rock Salt. *Cypris punctata, C. Purbeckensis,* Shells; *Rissoa, Planorbis,* 2 ft. 6 in. Very sandy Limestones with casts of fossils, 3 ft. Shales and Limestones, ending with cream-coloured slaty Limestone, 5 ft.	21	0
		Sandy Partings	1	0
	p	Broken Bands.* Shattered, slaty Limestone, with included fragments of flint; lines of stratification destroyed ..	10	0
	q	Soft Cap. Bands of Limestone, undulating over *Cycas-stools* in the bed beneath	5	0
	r	Hard Cap. Tufaceous Limestone, with masses and occasionally layers of flint overlying	4	6
		Dirt Bed	1	0
		Total	176	0

C. Portland Stone. Oolitic Limestone: Fossils, *Ostrea, Cardium dissimile, Ammonites giganteus, &c.*

The upper beds at Lulworth Cove contain a shelly limestone (better known as Purbeck Marble) a material seen in many of our older churches. It has been lately used in the interior of the beautiful memorial church at Kingston (Isle of Purbeck) built by the present Lord Eldon.

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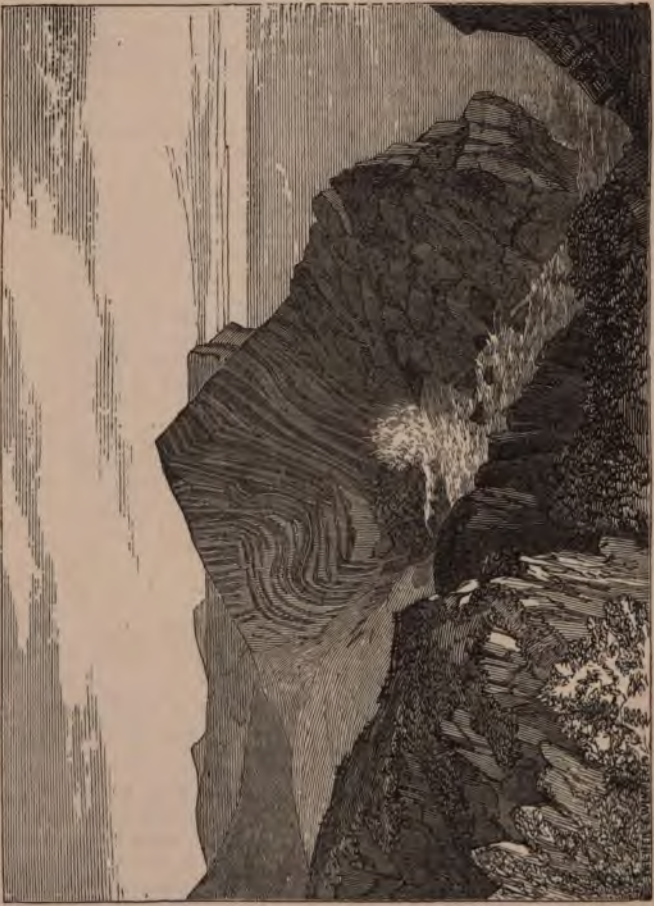
* On the origin of this very singular bed, the Rev. O. Fisher offers the following suggestion:—That the bed in its earlier stage was filled with branches of trees and other vegetable accumulations, over which a superficial deposit of mud and other sedimentary matter was thrown down, which subsequently giving way, the upper beds fell in upon the vacuity, in the confused manner in which they now appear. 'Cambridge Phil. Trans.,' vol. ix. 1855.

The remarkable bed which is exposed on a platform of the cliff,

Fig. 45.



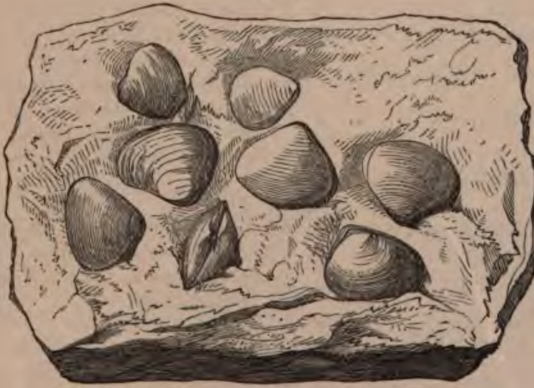
Strata at Stare Cove, west of Lulworth Cove.

three-quarters of a mile east of the Cove, and previously described under "Portland," p. 114, should be visited.

NOTE.—"Layers of pseudomorphous crystals of Rock Salt." A somewhat similar process is now going on in the shallow salt lakes of the Caspian region, formed by the winter rains which become impregnated with salt from the surrounding strata. Water of these lakes evaporates during the summer heats, leaving large saliferous deposits. Such dried-up lakes and marshes abound in the "Steppes" around Astrakhan and the Caspian Sea.—R. D.

"Beef," layers of which are so often repeated throughout the Purbeck formation at Ridgway, Lulworth, &c., is a fibrous carbonate of lime, with a texture resembling fossil wood, and is known to the quarrymen as "beef," "horse-flesh," "bacon," &c. The fibres shoot upwards from the bed of bivalve shells. From this Mr. Fisher supposes that their production is due to a change in the condition of the shells on which they rest.

Fig. 46.



Purbeck Limestone, with Cyclas.

It will be seen from Fig. 44 that the Purbeck beds at this point are not only raised in common with the adjacent portions of this formation so as to form a considerable dip, but that they are also curiously contorted, either owing to lateral pressure or partial subsidence.

DIVISION of BEDS in the PURBECK STRATA, RIDGWAY HILL, from 'The Purbeck Strata of Dorsetshire,' by Rev. Osmond Fisher, already quoted, and grouped according to the classification of the late Prof. Edward Forbes:—

UPPER.

Character of Rock.	Thickness. ft.	in.	Organic Remains.
Paludina Clays	5	10	Fish-teeth—Paludina, Cypris.
Upper Cypris Shales and Clays	10	4	Fish-teeth and Scales—Turtle, Unio, Paludina, Cyclas, Cypris. Wood.
Unio beds	12	6	Unios, 2 species, Fish-teeth, Paludina, *Anodonta Purbeckensis*, Forbes.
MIDDLE.			
Upper broken-Shell limestone	10	6	Comminuted Shells.
Chief Beef beds	4	6	Ditto.
Corbula beds	12	6	Bands with Shells, Fish-teeth, Turtle.
Intermarine	6	0	Thracia, Modiola, Perna, Pecten.
Freshwater	7	5	Cypris, crushed Bivalves, broken Ostrea washed out of cinder bed.
Cinder bed	5	2	Ostrea distorta—Cardium. Bones of Saurians. Turtle. Physa.
Cherty Middle Fresh-water ..	5	0	Paludina, Planorbis, Valvata, Melanopsis, Cyclas — Cypris, Pinna. Plants.
Marly Middle Fresh-water ..	11	6	Physa, Hydrobia, Cyclas, Cypris.
Upper Insect-beds	5	1	Elytra of Beetles, numerous.
Soft Cockle beds	16	4	Cypris, Serpula, Corbula, Cardium, Modiola, Leda.
Hard Cockle beds	8	8	Cardium, Rissoa, Cypris.
Lower Insect-bed	7	3	Elytra of Beetles, Fish Scales.
Cypris Freestone	25	1	Carbonaceous specks—Fish-scales—Cypris.
Broken Bands	9	3	Valvata helicoides, Lymnæa physoides, Cypris.
Hard and Soft Cap	6	8	Fossil wood, Fish (Histionotus breviceps), Cypris, Paludina.
Portland Stone.			
Total ..	190	9	

The above comprises 162 distinct and remarkably well-defined beds, suggesting innumerable changes of condition, as they include

Marine, Land, and Fresh-water deposits. Since the completion of the railway-cutting, these numerous beds are imperfectly seen except when a fresh opening of the face of the embankment is made. The section is tabulated and described in the 'Cambridge Philosophical Trans.,' and is given in full in the first edition of 'Geology of Weymouth,' &c., pp. 107–114.

The Fresh-water shells of the "Purbecks" so closely resemble living forms that it might have been impossible to refer them to any particular geological age, but from the circumstance of their being met with in their respective rocks. They chiefly differ from those that are at this day to be met with in the adjacent ponds and in brackish water, in their fossilised condition, notwithstanding the immeasurable time that has intervened between the two epochs.

Referring to the unexpected discoveries of Fresh-water shells in the Purbeck beds, Prof. E. Forbes, with his well-known humour, wrote the following amusing verses :—

"Down among the Purbecks deep enough,
A *Physa* and *Planorbis*
Were grubbed last year out of fresh-water stuff,
By Bristow and E. Forbes.

(Agassiz just had given his bail,
'Twas adverse to creation,
That there should live pulmoniferous snail,
Before the chalk formation.)"

Geikie's 'Life of Forbes,' p. 461.

The following fresh-water forms are found living within the range of the Dorsetshire Purbecks: *Cypris, Cyclas, Hydrobia, Valvata, Physa, Planorbis, Paludina, &c.*

Chalbury and Sutton.—Three miles north of Weymouth, there are numerous sections of the Purbeck and Portland Series. The first quarry or cutting, near the boiling rock,* is in a convenient situation for working, but from the inferior quality of the stone, it has been abandoned. A little farther up the hill on the right, stone is quarried both for building and lime-burning. Portions of the Portland Stone are here white like chalk. Their similarity to the latter formation is further strengthened by the presence of large coated flints, similar to those occurring in the Chalk. The stone is fine in texture, and breaks with a conchoidal fracture. From the absence of the more "oolitic" strata, and the scarcity of fossil remains, the beds are not easily made out. The top strata, which belong to the lower Purbecks, are much shattered, partly perhaps from exposure. The Dirt Bed is not distinguishable, and its presence might be considered doubtful, but for some fragments of fossil wood which are occasionally met with.

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* So called from its being the springhead of the stream which for many years supplied the town of Weymouth with water.

The passage of the Purbeck strata into those of Portland is not distinct, though the latter is determinable by means of one or two well-known fossils. No open fissures occur here as in the Isle of Portland. Crystallised carbonate of lime fills cracks and other interstices of the stone, which under similar circumstances in Portland are coated with stalactite. Among the few fossils to be found are *Ammonites giganteus, Trigonia incurva, Myacites Jurasii, Pleurotomaria rugata, Crustacean* impressions, &c.

In another quarry at Loddon, two hundred yards to the west, there is a section of the Middle Purbecks, which appear to agree with that portion of the series displayed in the Ridgway Railway cutting, and where the following fossils have been found :—

Megalurus Damoni, Egerton.
Palatal Teeth, *Scales*, and other Fish-remains.
Cyclades, abundant.

HASTINGS SANDS (WEALDEN).

Although occupying a small geographical area or extent, the Hastings Sand is of considerable geological interest, as evidencing the existence of dry land after and before its submergence. Mr. C. Weston was the first to establish the presence of this member of the Wealden at Ridgway,* where, in a cutting on the south side of the railway tunnel, variously coloured clays are exhibited characteristic of this formation. In a stiff blue clay near the base of the series, and just above the Purbecks, portions of colossal Dinosaurian herbivorous Reptiles have been found, referred to the genera *Iguanodon, Hylæosaurus* and *Megalosaurus;* also the stems of a peculiar plant, *Clathraria Lyellii.* Some of these remains are deposited in the County Museum in Dorchester.

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* 'Proc. Geol. Soc.,' vol. iv. p. 250.

In the same formation near Osmington Mills, Reptilian remains have been discovered. Owing to the proximity of the Kimeridge Clay and Wealden in this spot, their separate identification is not always clear. On both sides of Lulworth Cove, the Hastings Sands partake of the disturbed character of strata in that locality, and occupy a nearly vertical position. (See Pl. 44.) Their prevailing colour is a dull yellow, with occasional bands of a darker hue. The lower portion contains much iron ore, and its deep rusty colour forms a striking contrast to the main mass of the white chalk cliffs at the upper end of the Cove. Casts of fossils are sometimes met with in nodules towards the top of the cliff. There is a further extension of the Hastings Sands, east of Worbarrow Bay.

NOTE.—Throughout the entire section of the Wealden Beds on the coast of Sussex, over a distance of 18 miles, Mr. Beckles detected a series of foot-prints of great dimensions, and from their general uniformity of character, position, and direction it has been inferred

First. That *bipedal* animals having tridactyle feet of enormous proportions lived during the Wealden epoch.

Secondly. That the alternation of right and left footsteps proves the animals to have been biped.

Thirdly. That the numbers and positions of the toes seem to ally these animals to Birds; while, however, it may be regarded as undetermined whether these gigantic creatures were birds, or reptiles with ornithic characters.—'Quart. Journ. Geol. Soc.,' 1854, vol. x. p. 462.

Mr. Beckles further states that he observed a footprint measuring 27 inches in length by 24 inches in width, with a stride of 42 inches.

There is in the Geological Society's Collection, a large slab of Purbeck Limestone, on the surface of which are two large footmarks, resembling those from the Wealden, each measuring 12 inches in length. The occurrence of these singular memorials may therefore be looked for in the same formations of this district.

CRETACEOUS SERIES.

Upper Greensand.

Characteristic Fossils.

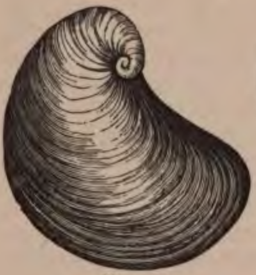

Fig. 47.

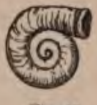

Fig. 48

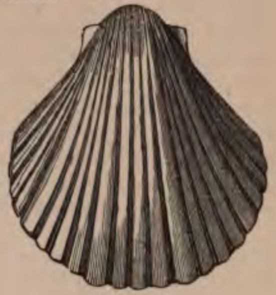

Fig. 49.

Fig. 47. *Exogyra conica.* Nat. size.
Fig. 48. *Vermicularia concava.* Ditto.
Fig. 49. *Pecten quadricostatus.* Reduced.

From the Upper Greensand, Osmington Mills and White Nore.

The above term, though applicable to the Greensand of this district, is not always so appropriate, since in some places it is not green, while in others it is not of a sandy nature. Usually it is composed of a silicious or siliceo-calcareous sand, mixed with minute spangles of mica, and specks of green earth* (Glauconite), from which last it derives its distinguishing colour. In the absence of the latter substance it is yellowish or grey. This formation generally attains a considerable elevation, being 800 feet above the level of the sea near Warminster; Blackdown Hills, near Lyme Regis, 817; Charmouth, 800 feet: White Nore is its highest point near Weymouth.

Immediately underlying and conformable to the Chalk, and having the same dip to the north, of about 20°, it appears to follow the course of that formation through Chaldon, Holworth, Bincombe, &c., to its western termination at Abbotsbury, small outlying patches being occasionally visible throughout that distance. Where the *whole* of the Greensand series is present, the section is as follows:—

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* These green particles are of the same nature as those in the Portland Sand, and consist principally of silica and protoxide of iron, with 10 per cent. of potash and 7 per cent. of alumina.—'Trans. Geol. Soc.' vol. iv. 2nd series, p. 109 (1836).

1. *Lower Greensand.*—This member of the group is not here distinguishable, though it may be included in a general mass of sand and clay under the Gault, which, on the east side of Lulworth Cove, Dr. Fitton reckons at 120 feet in thickness.*

2. *Gault.*—This formation is perhaps present at Lulworth Cove, but concealed by a bed of chalk-rubble. It may be recognised at the White Nore, though from the accumulated masses of fallen rock it is not always visible. Within an area of three miles the Upper Greensand rests successively on formations of five different ages, viz. at the White Nore on the Gault, Upton Valley on the Purbeck, Upton Hill towards the coast on Portland Stone, Osmington Mills on the Hastings Sand, and also on the Kimeridge Clay; an excellent illustration of unconformable stratification. In this instance the older rocks have been raised, so that the plane of the Greensand, the stratum above, rests upon their edges. In this way it is easy to see that, over a very small area, a series of older strata may be brought in contact with one of a much later period; the Greensand being deposited after the strata below had been raised out of their horizontal position and denuded.

3. *Upper Greensand.*—To this part of the Series is referred the Greensand at the following points.

WHITE NORE CLIFF.—A fine section estimated at 100 feet in thickness, and interspersed with large cherty nodules.†

FOSSILS from the GREENSAND, WHITE NORE, and OSMINGTON MILLS.—At the latter locality the Upper Greensand forms the crest of the hill overlooking the romantic little village of Osmington Mills, and where we find the following fossils:—

Shark's teeth.
Cardiaster suborbicularis, Defr.

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* 'On the Strata below the Chalk,' p. 216.

† To which are equivalent the concretions of the Whetstone Pits of the Upper Greensand of Blackdown in Devonshire, from which scythe-stones are obtained.

Pecten quadricostatus, Sow.
" *quinquecostatus*, Sow.
" (a small species).
" *asper*, Lam.
" *orbicularis*, Sow.
Exogyra columba, Lam.
" *conica*, Sow.
Ostrea (?)
Gryphæa vesiculosa, Sow.
Vermicularia concava, Sow.
Serpulæ.
Stems of *Siphoniæ*.

About a mile west of Osmington Mills, high up in the cliff, the Upper Greensand contains large stony lumps of a grey colour (Fire Stones) in which fossils—chiefly casts—are abundant.

Ammonites, one or two species.
Hamites.

Astarte impolita, Sow.
Cytherea plana, Sow.
Cucullea glabra, Park.
Cypricardia.
Cardium Hillanum, Sow.
Exogyra columba, Lam.
" *conica*, Sow.
Inoceramus concentricus, Park.
Modiola.
Pecten orbicularis, Sow.
" (small species).
Pectunculus umbonatus, Sow.
Trigonia alæformis, Park.
Venus, one or two species.

Vermicularia concava, Sow.

Notwithstanding the small number of species referred to the Greensand of this district, it is in some places distinguished both for the number as well as for the beauty of its fossil shells, 150 species being recorded from the Blackdown Hills alone.

Like the Chalk, the Greensand of Dorsetshire presents many high and insulated masses intersected by valleys and plains.

CHLORITIC MARL.

As the Upper Greensand passes insensibly into marly chalk, so the latter graduates into the Lower Chalk. The Chloritic Marl was formerly assigned to the Greensand series, but is now included with the Chalk. At the White Nore it forms the base of that formation. It is generally of a grey or pale-yellow tint, occasionally greenish, arising from particles of Green Earth (Glauconite), which assimilates it to the beds of Greensand beneath. Small grains of white quartz characterise this stratum, and impart to it a degree of hardness sufficient for architectural uses. The Chloritic Marl is remarkable not only for the number of its organic remains, but for their interesting and singular character, many of which are peculiar to this formation and have no counterpart in existing genera.

Fossils from the Chloritic Marl of White Nore, generally from the surfaces of large blocks on the shore, recently dislodged from the cliffs above :—

Fish-teeth and *Coprolites.*

Ammonites varians, Sow.
Nautilus lævigatus, D'Orb.
Turrilites costatus, Lam.
Scaphites æqualis, Sow.
Hamites.
Baculites.

Pleurotomaria depressa, Sow.
Natica.
Avellana.

Unicardium.

Terebratula semiglobosa, var. *subundata.*

Holaster subglobosa, Dixon. Abundant.
Discoidea subuculus, Leske sp.
Micraster (*Spatangus*).
Galerites castanea, Forbes.

Recently there has been a landslip at the White Nore, covering several acres and bringing down masses of chalk from the upper part of the cliff.

CHLORITIC MARL. Characteristic Fossils.

Fig. 50.

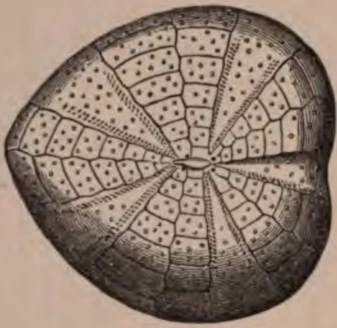

Fig. 51.

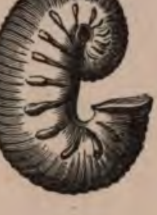

Fig. 52.

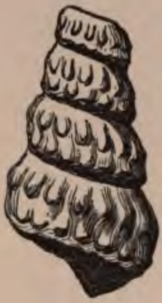

Fig. 53.

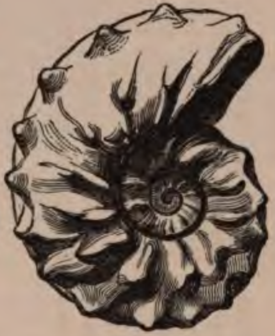

Fig. 50. *Holaster subglobosa*, Dixon. Nat. size.
Fig. 51. *Scaphites æqualis*, Sow. do.
Fig. 52. *Turrilites costatus*, Lam. do.
Fig. 53. *Ammonites varians*, Sow. do.
All from the Chloritic Marl of White Nore, near Weymouth.

At Lulworth on the coast, the Chloritic Marl yields the same species as above, though more sparingly in numbers.

Small patches of this formation appear at intervals towards the summit of the Chalk ridge from Bincombe Down westward.

The Chalk Marl occupies a naturally useful position in Chalk districts, as from its impermeable character it holds up the water which percolates through the more porous chalk,* and if, from some exceptional cause, water is not thrown out by this bed, it is generally found necessary to pass through the sands beneath to a considerable depth.

NOTE on Water-bearing strata.—

Permeable.	*Impermeable.*
Chalk.	Chalk Marl.
Green Sand.	Gault.
Purbeck Beds.	Kimeridge Clay.
Portland Beds.	Oxford Clay.
Coral Rag.	Fullers' Earth.
Great Oolite.	Lias.
Inferior Oolite.	

"The transmission of rainwater through the chalk is so slow, that it takes four to six months to pass to a depth of 200 to 300 feet; so that the heavy rainfall of winter is not felt in the deep springs until the summer; and the maximum effect of a hot dry summer is often not reached until the end of about sixteen months." †

The Weymouth water, so celebrated for its purity and general excellence, is derived from the Chalk Marl, where, at the picturesque village of Sutton,‡ the water is raised to a reservoir from this stratum by a "Turbine Engine," and a high-pressure supply is thus given to the town on both sides of the Harbour.

The much-frequented springhead or "wishing-well" at Upwey, throws out a copious supply from a similar source. There are also springs at Bincombe.

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* At Lulworth Cove, a stream finds an outlet from the base of the chalk.

† Mr. Beardmore, 'Minutes of Evidence,' House of Commons.

‡ There is here a small stone bridge in good state of preservation, which has been said to be of Roman age, though on a recent visit of the Archæological Society to the County, it was referred to early Norman.

CHALK.

The South-western termination of this formation, so characteristic of the English coast, is in the cliffs of Dorsetshire and Hampshire, and it has been conjectured that the bed or area from which it has been severed passes under the English Channel and Atlantic Ocean, until it reappears on the S.E. coast of the North American Continent. Should this supposition be correct, it is reasonable to suppose that the whole of this part of the Atlantic area has continued submerged from the period of our Chalk; while the continent of Europe has been successively raised and submerged. There are also palæontological evidences leading to the same conclusion, as many forms of life, especially among the *Crinoidea*, *Echinoidea*, and *Brachiopoda*, now living in the Atlantic, have, in the opinion of many Naturalists, been transmitted in unbroken succession from the epoch of the Chalk formation.*

Atlantic mud collected during the first cruise of the 'Porcupine,' in 1869, gave the following results:—

	per cent.
Carbonate of lime	50·12
Alumina	1·33
Sesquioxide of Iron	2·17
Silica	5· 4
Rock débris	26·77
Water	2·90
Organic matter	4·19
Chloride of Sodium and other salts ..	7·48
	100·00

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* Prof. Prestwich writes that the hypothesis in regard to the continuity of the sea-bed of the Atlantic from the period of the chalk to the present time, is one of high probability.—'Quart. Journ. Geol. Soc.,' vol. xxvii. p. 64.

Chalk in its pure state is composed of carbonic acid and lime, and consists of an aggregation of the hard parts of certain microscopic organised forms which lived in that ancient ocean of which the Chalk area was the bed.

p. 135.

Pennant, in describing the range and extent of the English Chalk, refers to that portion which spreads over the counties of Wilts and Hants as the centre and source whence it diverges into several branches. Mr. Conybeare gives a figure of the letter placed thus, with the lower part of its stem bent inwards, as representing the direction of these various chains, one of which, indicated by the lower arm, is thrown off from the south-east angle of the central mass, passes to the sea at Beachey Head, and thence south through the Isle of Wight to its termination at White Nore. From the latter point it proceeds inland, as may be seen at Ower Moigne, where the turf and surface soil having been removed from the chalk they covered, a colossal figure in white of George III. on horseback is visible on the slope of the hill, facing Weymouth.* Some remarkable features of this formation are displayed on this coast, where the Chalk strata present every degree of inclination, until they assume an actual vertical position. At Bat's Corner, West of Lulworth Cove, the strata of Chalk with layers of flint are nearly vertical (see Plate, Fig. 54). Half a mile west the Chalk is horizontal, these two points being united by a set of curved strata. At other points, east and west of Lulworth, the Chalk is also curiously contorted, while at Handfast Point it again becomes almost vertical; a condition of the strata that might have been caused either by subsidence or upheaval. In no way can this singular stratification be so well seen as from the deck of a steamer.

Sir H. T. De la Beche subdivides the Chalk of Dorsetshire as follows :—

1. Chalk with Flints.
2. Chalk without Flints.
3. Chalk with Quartz grains.

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* It measures in height 174 feet. A somewhat similar work on the Chalk Hill near Cerne Abbas (Dorset) of a Giant holding a club is 180 feet in height. "Maiden Castle," on the Chalk Downs near Dorchester, covers 150 acres, with five lines of entrenchment. This early fortification was begun by the Ancient Britons, but was rendered more complete and secure by the Romans. It is considered to be the most remarkable work of its kind in Great Britain.—(See 'Celtic Tumuli of Dorset,' by Charles Warne, F.S.A.)

The above may I think be further subdivided into

1. Chalk with Flints.
2. Chalk with few Flints.
3. Chalk without Flints (Hard Chalk).
4. Chalk Marl and Chloritic Marl.

It is nevertheless true that until the Chalk Marl is reached (the true base of the Chalk), "there is no hard line anywhere in the Chalk deposit."

The thickness of the Chalk at Blackdown, near Weymouth, is estimated at 800 feet.[*] (See De la Beche's Report, 1839, p. 249.)

NOTE.—On the Antrim coast of Ireland the Chalk has been changed into hard crystalline limestone under the combined influence of heat and pressure, occasioned by the eruption of volcanic rocks (Basalt). In the vicinity of Moscow, the Carboniferous Limestone is a white chalky rock, in which fossils of the Carboniferous Limestone are numerous; and in a district of North Germany, the only white chalk strata are those of the Tertiary age. In such and similar cases the nature of the fossil determines its true character and age.

Chalk is not necessarily white, as in parts of Lincolnshire the lower part consists of red and white layers, each lying in regular strata.

The cretaceous rocks about Jerusalem are more or less tinted with red, in patches, which colour has been ascribed to supernatural causes. The stone of unction in the Church of the Holy Sepulchre is from an adjacent quarry, and the rock being somewhat hard and of close texture, is there named "Jerusalem Marble."

High Hills and absence of trees characterise Chalk districts.

Organic remains, though generally numerous, are not so in this

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[*] The following are amongst the highest summits of the Chalk Hills in England:—

Inkpen Beacon—its highest elevation in England ..	972 feet.
Butser Hill, Hants, summit of the South Downs ..	882 „
Hill north-west of Limpsfield, summit of the North Downs	876 „
White Horse Hill, Berks	856 „
Wilton Beacon, Yorkshire	809 „

neighbourhood, notwithstanding the extent of the formation and the large surface here exposed.*

List of Fossils from the Chalk at White Nore.†

Fish Remains :—Teeth, Coprolites.
Ammonites Coupei, Brong.
　„ *euomphalus*, Sharpe.
Nautilus.
Belemnites mucronata, Mant.
Inoceramus Brongniarti, Sow.
Lima.
Pecten quinquecostatus, Sow.
Rhynchonella plicatilis, Sow.
　„ *pectita.*
Terebratula carnea, Sow.
　„ *semiglobosa*, Sow.
　„ v. *subundata*, Sow.
Ananchytes ovatus, Forbes.
Holaster planus, Mant.
Galerites abbreviatus, Lam.
Micraster rostratus, Mant.
Salenia.

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* The following divisions of the soils is given in the Agricultural Report of the County of Dorset by Stevenson :—

Chalk	160,759	acres.
Sand	85,157	„
Loam	37,746	„
Gravel	59,894	„
Cornbrash	29,700	„
Clay	117,331	„
Miscellaneous	13,427	„

Total 504,014, exclusive of Rivers, Roads, Towns, &c.

† The Chalk Cliff at the White Nore is the home of the following Land Molluscs, viz. :—*Helix* (Caracolla) *lapicida*, *Helix nemoralis*, in endless varieties, and the pretty and only species of British Cyclostoma (*Cyc. elegans*). *Patella athletica* and *P. vulgata*, of unusual size, are to be met with on rocks up to high-water mark.

NOTE.—The Upper Chalk of Great Britain is characterised generally by an abundance of fossils. Of foreign localities probably there is none yet explored so rich as that of the Lebanon, where, on the grounds attached to the Maronite Monastery, a few miles from Beirut, organic remains, especially of Fishes, are unsurpassed for the number of genera, species and individuals. Fish-teeth and other portions are plentiful in the British Chalk; but here entire Fishes in beautiful preservation, from the small *Clupea minima* (allied to the White Bait), to the *Squalidæ* (Sharks) abound. *Clupea minima* is found covering large surfaces; in many instances, the individuals equidistant from each other, as if a shoal had been suddenly arrested. Besides Fishes, these beds contain *Crustacea*, *Cephalopods*, *Comatula*, *Star Fishes*, &c. &c. Some of these are being described by Dr. Woodward in the 'Geological Magazine.' Dr. Lewis, Professor in the Protestant Syrian College of Beirut, whose acquaintance I had the pleasure to make when in Beirut, succeeded in forming a collection of considerable scientific value; several new genera and species being added to the list described and published by MM. Pictet and Humbert, 1850–1866.

Dr. Lewis has lately resigned his position in the College, but a great part of his collection has been secured by the Natural History Museum (Cromwell Road).

TERTIARY.

All strata deposited subsequently to the Chalk were,* until a very comparatively recent period, included in the Tertiary Series. No department of Geology has of late years received more attention and yielded more important results than the numerous formations now embraced under this division.

Strata formerly regarded as contemporaneous are now sometimes known to have been formed at widely separated intervals. There is, however, more difficulty in establishing the relative age of the Tertiaries than of the older rocks. The classification now accepted is based almost entirely upon their fossil remains, it being a safer course to consider those strata the most recent, the organic remains of which bear the closest resemblance to living forms. Existing species first make their appearance early in the Tertiary era. The older strata predominate in the North of England; the South and

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* The Upper Chalk in Great Britain, but on the Continent the 'Maestricht' beds form the uppermost part of the formation: the latter are not represented in Great Britain.

East are covered with the more recent deposits. It is on the borders of Dorsetshire that the English Tertiaries are so richly developed; there the Tertiary formations find their westerly termination, passing to the east through Corfe to Studland, Bournemouth, and the well-known cliffs of Barton and Hordwell (Hants). They reappear in the Isle of Wight, where they present a singular and highly interesting condition in the vertical and many-coloured sands of Alum Bay.

The sterile plains and heathy commons which cover so large a portion of the borders of Dorset and Hampshire, where traversed by the London and South-Western Railway, are beds of Lower Tertiary age.

WOOLWICH AND READING SERIES

(Lower Eocene),*

Formerly called "THE PLASTIC CLAY."

The surface of the Chalk is occasionally of a most irregular character; in some places it has been entirely removed, in others it is hollowed into furrows, basins, and variously-shaped cavities filled with Tertiary deposits, of which the lowest is the Plastic Clay, so named from the economic purposes to which some of its beds are frequently applied. Several outlying patches occur in the immediate neighbourhood under consideration; and to the north-east of Weymouth there are some extensive and valuable deposits belonging to this formation, which extends parallel to the Chalk from Lulworth to Studland Bay.

These clays, of different colours, white, grey, yellow, and red, are of different degrees of purity, and according to their qualities are described as brick-clay, potters'-clay, and pipe-clay. In the park at East Lulworth, variegated clays rest on the Chalk.

Bincombe Heath.—In the above division of Tertiaries are included those accumulations of flint-gravel and sand which on the summit of Bincombe Heath occupy deep cavities, and were lodged in their present recesses when that area was submerged beneath the sea. They consist of—

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* London, Paris, and Vienna are built on formations of Lower Tertiary age, which lie in large basins or concave areas of which the Chalk formed the then sea-bottom and shore.

1. Coarse and crystalline sand, with large flints and cherty masses, the latter containing casts of *Echini*, *Terebratulæ*, and other fossil shells from the Cretaceous formation.

2. Chalk-flints, mixed with more or less of sand, and gravel, with rolled flint pebbles.

3. At the highest point the material is of smaller size, with a large proportion of fragments of milk-white quartz, shivered into smaller fragments and partially rolled. In some spots the small pebbles are contained in a matrix of black earth. The locality has long been famous for a fine white sand, much valued for house building. These deposits, which have been largely worked during the construction of the adjacent railway, are repeated at Waddon and Blackdown to the west, and over a larger surface on the north-east of Weymouth. At Bincombe Heath the gravel and other beds are tilted in common with the older strata.

BAGSHOT SERIES.

(Middle Eocene.)

The clays at Corfe were considered by the late Mr. Joshua Trimmer to belong to the lower part of this series,* and his views have been adopted by the Geological Survey (Vertical Section No. 25, and Horizontal Section No. 56, illustrative of Map No. 10). The Dorchester and Southampton Railroad through Moreton and Wool passes over these deposits. The clay-pits are three miles from Wareham, and near to the village and ruins of Corfe Castle.†

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* 'Quart. Journ. Geol. Soc.,' vol. ix. p. 63.

† The Dorset county historian, Hutchins, states that King Edgar was probably the founder of this magnificent structure, though the first mention made of it in our histories is A.D. 978, upon occasion of the barbarous murder of Edward, King of the West Saxons, committed here by his mother-in-law, Elfrida. The castle was the residence of the West Saxon Princes, when they came to the Isle of Purbeck to hunt. It was also the place of confinement for persons of the highest rank. Here King John kept the regalia of the crown.

In the Civil War it was one of the last places in England that held out

LOWER BAGSHOT SANDS AND CLAY.

The clay-pits of this series represent one of the most important industries of the county of Dorset. The clay is worked over a large area, and by means of tramways shipped from Poole. The finer quality is used in the manufacture of china, and the inferior in earthenware, while the residue is utilised for the production of alum, &c.

The following analysis of the Corfe pipe-clay by Professor Way is extracted from a paper by Joshua Trimmer, F.G.S., in the 'Journal of the Royal Agricultural Society,' vol. xvi. part 1:—

	White Clay.		Black Clay.
Silica	65·49		72·23
Alumina	21·28		23·25
Oxides of Iron	21·26		2·54
Alkalies and Alkaline Earths ..	7·25		1·78
Sulphate of Lime	4·72		0·00
Total ..	100·00	Total ..	99·80

Section of a clay-pit near Corfe:—

	Feet.
Beds of Lignite, about	10
Grey Clay with carbonised leaves of plants	2
Yellow Sand with leaves	2
Ferruginous band, a few inches.	
White Sand, about	30
Pipe-clay, 11 to	14
Total ..	58

Kaolin, a fine quality of China Clay, is obtained in Cornwall from the decomposition of the Felspar in Granite; but as no such

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for the King. After a siege which lasted 48 days, it was taken Feb. 26, 1645, when it was plundered, undermined, and reduced to its present state of ruin.

See also 'Story of Corfe Castle,' by Mr. Bankes.

A description of the old town of Corfe, which prior to the passing of the Reform Bill of 1832 sent two members to Parliament, is given in a recent and attractive work, 'Picturesque Rambles in the Isle of Purbeck,' by C. E. Robinson, M.A. Its quaint architecture and grand old ruins are finely illustrated with numerous etchings. The county offers few, if any, spots of greater archæological and historic interest than Corfe Castle and its surroundings.

rock occurs in Dorsetshire, it has been conjectured that the Dorset Pipe-clay was derived from the decomposition of the Felspar in the Granitic rocks of Devonshire and Cornwall.

Palms and well-preserved leaves of many other kinds of plants may be collected in the clay-pits of Corfe. Insect remains found in these beds have been figured and described by Mr. Westwood in the 'Quart. Journ. Geol. Soc.,' vol. x. p. 381.

The lower freshwater beds are seen at Corfe and in the cliffs at Studland.

Bournemouth Clay Beds.

Of the same period (Middle Eocene) though somewhat beyond the scope of the present work, are the clay and sandy beds of Bournemouth, remarkable for the richness of their fossil Flora. This series of *white*, *grey*, and *brownish* coloured clays are seen in the cliffs between Poole Harbour and Bournemouth, from which beds no less than nineteen species of Ferns have been determined. The west side of Bournemouth is rich in *Polypodiaceæ*, and the east side in *Eucalypti*, and *Araucaria*. These, with other and sub-tropical forms, demonstrate the existence of a once luxuriant forest, extending to the Isle of Wight, where, in the cliffs at Alum Bay, are contemporaneous beds. The Flora of Corfe, Bournemouth, and Alum Bay, are identical. An increased interest has been given to the Bournemouth beds from the publications of Mr. Starkie Gardner ('Quart. Journ. Geol. Soc.,' vol. xxxv. p. 209, and vol. xxxviii. p. 1); see also numerous papers in 'Nature.'

POST-TERTIARY (PLEISTOCENE).*

Glacial or Northern Drift.

Traces of Man on the Earth appear for the first time at the close of the Tertiary series of formations, when the more regularly deposited beds terminate. In the newer and succeeding period, known as the Post-Tertiary, geological deposits and conditions are of a more irregular and diverse character. Some Geologists assign an earlier date and consequently greater antiquity to Man, and believe that there are proofs of his existence during the Tertiary epoch; but in the judgment of those who have thrown most light upon this question, there are as yet no reliable data to support such a view. Amongst the earlier authenticated evidences of Man in Britain, are probably the flint-flakes found in the Brick-earth of Crayford in Kent, first by the Rev. O. Fisher, and subsequently by other observers under similar conditions. Though there are indications that a colder climate for a time prevailed over this part of the country, they cannot be referred to the Glacial Epoch, more than can the deposits of gravel and other drift-beds on the higher lands surrounding Weymouth. These, together with a few scattered Boulders,* may be traced to rocks not very remote, whereas the great Glacial Drift, though widely spread, has not extended to the S.W. parts of Great Britain. The following extract will help to illustrate the effects of this latter agency:—

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* Sir C. Lyell, in the last edition of his 'Elements of Geology,' restricts the term 'Pleistocene,' or its synonym 'Post Pliocene,' to the lower subdivision of the Post-Tertiary.

> The overland route to Russia, viâ Konigsberg or Warsaw, reveals some instructive facts connected with one of the most recent yet extreme of climatal changes which has contributed to mould and fashion so large a portion of the surface geology of Northern Europe. I refer to the "Great Ice Age," or "Glacial Period."
>
> Soon after leaving the German frontier, granitic débris and small stones everywhere appear on the surface. These erratic granitic boulders increase in number and dimensions as the journey is pursued, so that in a few hours they have so augmented that a considerable distance might be traversed by stepping from one of these stones to another. Now and then there are some one or more of exceptionally large proportions, but taken as a whole, the increase in size is extremely uniform, and before the environs of St. Petersburg or Moscow are reached, many of them attain colossal dimensions. Having in my recollection the block of granite in the Admiralty Square in St. Petersburg (which is also a boulder), on which stands the equestrian statue of the Czar Peter, many of the boulders referred to are hundreds of tons each in weight. In some instances the railway has paid respect to their dimensions and avoided them, for no ordinary mechanical power could effect their removal.
>
> It is seen that the direction of the transporting power by which this vast mass of erratics has been sown broadcast, has acted from N. or N.E. to S. and S.W. Several specimens of granite, gneiss, &c., I was able to identify as having been derived from the granitic region of Finland, nearly

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* It should, however, be stated that a granite-boulder was a few years since seen at Wolverton by the Rev. O. Fisher and Mr. H. W. Bristow. There is also one at Fordington, both being places near Dorchester.

1000 miles distant, while others have been traced to the rocks which surround the shores of Lake Ladoga, immediately north of St. Petersburg.

The amount of material transported is not to be judged merely from what appears on the surface. When an excavation has been made and the soil removed, boulders are exposed piled one upon the other in heaps to an enormous depth, recalling to mind the accumulated masses of rocks on the shore of a lofty line of coast. These quarries in the boulder formation being, humanly speaking, inexhaustible, are a source of valuable building-material to a district where no other stone can be obtained.

This enormous tract consists of almost unbroken alluvial plains, as boundless as the ocean, without a tunnel, a cutting, or a bridge being visible through an entire day's journey. The railroad is so straight and the scenery so monotonous, that the traveller can hardly realise his onward progress; the track seems ever to converge towards opposite vanishing points on the horizon both in front and behind.

The boulders are frequently used as tomb-stones; but no tool is applied to them save for the inscription, which is brief and simple.

('The Great Northern Drift,' by R. Damon, F.G.S. 'Geol. Mag.,' dec. ii. vol. v. p. 403; 1878.)

BONE CAVERNS.

Quarrying operations in the Island of Portland lead to the discovery of accumulations of bones belonging to extinct quadrupeds, mingled with others of existing species. In the year 1840 a heap equal to several cartloads was removed from a Quarry on the north-east side of the Island, where, among others, the following were identified:—

Head Bones of a large Boar (still preserved in Portland Castle).

Bos Urus, a large wild Ox, a species only recently extinct, being seen, it is said, by Julius Cæsar on his invasion of Britain,—Skulls, and Antlers of one or more kinds of Deer. Bones of the Horse, Wolf, Dog, Sheep, and Mouse. Teeth of an extinct species of Horse. The above were recognised by Dr. Buckland and Mr. Conybeare shortly after they were transferred to a local Museum. During the construction of the Vern fortifications fissure-bones were of not unfrequent occurrence. In the Museum of the Engineer's Office portions of the following animals are preserved, viz. *Megaceros Hibernicus* (Irish Elk), *Cervus Tarandus* (Rein Deer), *Bos longifrons*, *Bos urus*.* From remains of the above animals having been sometimes found in proximity to human bones, it has been said that both kinds have been found in common; but this is not so, as the latter are interred remains,[*] a few feet beneath the surface, though a stray bone or two may have found its way down a fissure where bones of other animals had been deposited. These fissure-bones, though not in a fossilised state, are of great antiquity, being lighter and more fragile than recent bones, though still retaining a portion of animal matter.[†] Their preservation in caves and fissures is in great measure due to the stalagmitic deposits which cover the ground and fill up the interstices around them, thus protecting the bones from atmospheric action, an exposure to which would soon decompose them. Though the bones are generally removed before the conditions under which they occur can be examined by those who are aware of the points on which information is most important and desirable, the quarrymen agree in stating that they are found in or near a gully (fissure) which has now no direct communication with the surface immediately above. The question "How came they in this situation?" may perhaps receive a solution in one of the following conjectures.

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* A list of remains of Archæological and Geological interest, discovered in the neighbourhood of Vern Hill, is given towards the end of this volume.

1st. "That these caverns and fissures afforded recesses that were the resort of beasts of prey, the bones being the remains of animals that had been devoured by them for their food." At Kirkdale Cave the bones have the appearance of being broken and gnawed by the teeth of Hyænas and other carnivorous animals. The bones, however, from the Portland fissures present no such appearance.

2nd. "That the animals spontaneously entered the place in which they are found, or had fled to it as a refuge from some general convulsion." To this it may be said that, with regard to the larger animals, the Portland fissures are not of sufficient width to admit of this explanation; yet they might have once communicated with some larger and lateral openings or approaches, all traces of which have since disappeared.

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[*] Some of these bones, judging from associated relics, date from the time of the Roman occupation; others may be referred to the time of the Civil Wars, when the Isle of Portland was the scene of several contests. In one instance sepulchral remains of the Romano-British period were discovered, including a stone coffin, now in the courtyard of the convict prison, which contained the bones of two persons, supposed to have been male and female.

[†] The tongue, when applied to ancient bones found in caves and fissures, adheres, as is not the case with regard to human and other bones of later date, which retain too much animal matter or gluten to admit of this test.

3rd. "That the bones were those of animals that had fallen into the open fissures from above." In Duncombe Park, Helmsley, in Yorkshire, and in Monmouthshire, Glamorganshire, and other limestone districts, such open fissures may have formed traps to the animals that roamed there. In Portland the fissures do not now reach the surface; nor is there evidence that they have done so within the Geological period to which these deposits are referred.

4th. "That they are the bones of animals drowned and drifted into their positions by the waters of a flood."

When cave—or fissure—bones are mingled with loam and gravel, it may be inferred that they were so lodged. In the absence of any violent inundation, subterranean streams may have had something to do with the bringing together of these accumulations. Although, of the four hypotheses above given, the last appears to be the most probable origin of the Portland fissure-bones, it must not though be overlooked that the face of the country has been greatly changed since these animals found in this part of Great Britain the food, range, and other conditions most necessary to their existence.

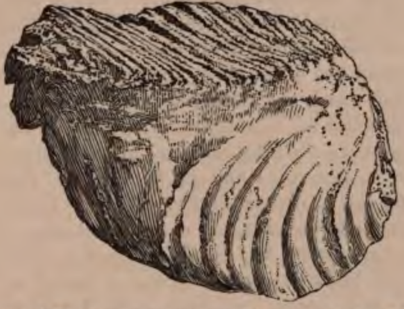
The period when the bones found in caverns and fissures were deposited has not yet been determined. In many instances the bones of the rhinoceros, hippopotamus, tiger, bear, lion, and other animals of the drift period, have been found mingled with human remains; as in Kent's Cavern and Brixham Cave, near Torquay, where relics of human workmanship were associated with the bones of extinct quadrupeds.

POST TERTIARY (PLEISTOCENE).

MAMMALIFEROUS DEPOSITS, OR ELEPHANTINE PERIOD.

Characteristic Fossil.

Fig. 55.



Molar Tooth of *Elephas primigenius*. Blumenbach.* (Mammoth.)

With deposits of clay, loam, and gravel, not occurring in stratified order, but as superficial and irregular accumulations, are concealed the remains of animals supposed to have become extinct anterior to the human period, and of others that survived to the age of tradition. Of these the most remarkable and most widely distributed is the fossil Elephant † (*Elephas primigenius*), or Mammoth, of which the skeleton in the Museum of the Academy of Sciences at St. Petersburgh is a well-known example. This grand and unique specimen, taken from the frozen soil of Siberia, with its skin and hair preserved, measures in height 12 feet, and in length 16 feet 4 inches; length of tusk, 9 feet 4 inches.

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* On the coast of Norfolk the teeth of Elephants, collected within the present century, are said to have belonged to 500 different individual animals.

† As further illustrating the altered conditions of continents, a small and extinct species of Elephant occurs fossil in the Island of Malta; while at Pikermi (Greece) in the Miocene formation, are found bones of animals, some of extinct species, and others of species still living on the opposite Continent, from which Greece has within a recent geological period been severed. A fine collection of these somewhat remarkable fossils is exhibited in the new museum of modern Athens, viz.: *Giraffe* (two species), *Mastodon*, *Dinotherium*, *Hyæna*, *Antelope*, *Rhinoceros* (two species), *Ape*, and especially to be noted *Hipparion*, "Little Horse" (Tridactyle), the often-cited intermediate form, between the "*Anchitherium*" and the modern Horse, with many others.—R. D.

Numerous molar teeth and bones of this gigantic animal have at various times been dug out from the upper end of the Weymouth backwater near Radipole Parsonage, in a deposit of angular flint-gravel, which deposit, derived from strata not far remote, extends beyond the present bed of the river, and contains also Deer Antlers, Hazel nuts, drift-wood, &c. Mammoth teeth have likewise been discovered in the following adjacent spots :—Chesil Bank, off Abbotsbury, washed up from the Channel-side; gravel beds on the grounds of Lord Eldon at Encombe, and in the Isle of Portland at an elevation of 400 feet above the level of the sea. This latter site is, from its elevation and isolation, one of much interest.

From a Crown quarry Mr. Neale obtained a tusk and several grinders, 15 feet below the surface, from a deposit of loam, sand, and débris of local rocks, in which Prof. Prestwich afterwards recognised small blocks of the hard sandstone, or Sarsen Stone, from the Lower Tertiary. These materials occupied a depression in the Upper Purbeck and Portland Beds. Since the first discovery, other teeth have been taken from the same situation, reported by Mr. Busk to include a well-marked molar of *Elephas antiquus*, and portions of that of *Elephas primigenius*: thus associating a former geological condition of this district and other parts of Great Britain with that of the remote region of Eastern Siberia. Considerable interest surrounds all that relates to this remarkable animal, for it not only gives us a glimpse of past life on the earth, but points to the time when Britain may have formed part of a continent extending to the Polar regions.

Unlike other Elephants, the Mammoth lived in various climates, their remains having been found in nearly all lands throughout Europe and Asia, though nowhere so numerous as in Eastern Siberia. Middendorf estimates the number of tusks sent to Europe as fossil ivory, since the conquest of Siberia, as belonging to 20,000 animals; while of molar teeth a cargo is shipped from Archangel every third year. Bones, being less favourable for preservation, are much less common. Of entire animals I only know of two examples (both which are in the National Museums of Russia), probably from the difficulty and cost of exhuming and transporting such colossal remains.

Sir R. Murchison observed a superstitious feeling in respect to these remains on the part of some of the natives, who have been known to say to the miners who first settled among them, "Take from us our gold if you will, but for God's sake leave us the bones of our ancestors."* Other opinions now prevail in Siberia, as I found all such scruples readily yield to *English* gold.

CHALK FLINTS, BRECCIA, AND ANCIENT DRIFT.

Cavities in the Chalk, filled with angular flints, washed out of its own mass, are not unfrequent, and of such there are instances at altitudes ranging to 730 feet at Came Down, Upton, White Nore, and Abbotsbury.

Section of Lower Eocene gravels in the ballast-pit opened for ballasting the railway on Bincombe Down.—This shows the position of the tabular flints containing the remarkable casts of the cretaceous fossils. Similar casts are found in the great mass of drifted flints at Haldon Hill, near Exeter.

1. Vertical Chalk.
2. Yellow Clay.
3. Sandy Pipeclay.
4. Rounded Flints and Gravel Flints, black inside.
5. Sand and laminated Clay.
6. Tabular blocks of Chert with casts of fossils.
7. Subangular Flints, Gravel used for the Weymouth road.

Approximate thickness of section, 24 feet.

The Rev. O. Fisher, to whom I am indebted for the above section, further informs me that the deep cuttings "showed the beds to be vertical, following the dip of the Chalk, and these have much the character of those at Bournemouth, except that they are coarser. The manner in which the ends of the vertical beds are bent over, and washed down the slope of the hill, is particularly well shown."

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* Sir R. Murchison, 'Geol. of Russia,' vol. i. p. 491.

For the literature of Mammoth finds, see Baron Nordenskiöld's 'Voyage of the Vega,' vol. i., and Howorth's "Mammoth in Europe," 'Geol. Mag.' 1882.

Mammoth bones were known to early English writers, who considered them as the remains of Giants. At a more remote age they were conjectured to be the bones of fallen Angels.

Referring to which, Prof. Prestwich says, "Capping the high Chalk ranges of Upton, the White Nore, and Abbotsbury, is a thick bed of perfectly angular sharp chalk-flints in a reddish clay reposing on a deeply indented surface of Chalk, while a similar angular drift, composed of fragments and masses of chert and ragstone, caps the Upper-Greensand hills N. of Abbotsbury. I refer to them as having been the storehouses whence much of the latter drift-beds have been supplied."* In an article by Searles V. Wood, Esq., "On the newer Pliocene period of England," the author, after quoting Prof. Prestwich, remarks that "these deposits seem to correspond with the Meadsted bed in the time and mode of its origin; so that the evidences of the maximum submergence (of the Chalk formation) seem in Hampshire and Dorsetshire to differ but little from those in the Cotteswold region."† Beds of gravel and other débris are also found in other situations, resting on formations of various ages: as for example, on the cliff east of Osmington Mills, and the hill to the right of the turnpike road from Weymouth to the Village of Osmington. Others in road-cuttings, pits, and hollows, S.W. through the villages of Preston, Broadway, Chickerell, to and beyond Abbotsbury. Also between Wyke and the Portland Ferry bridge, and again on the North towards Dorchester. These ancient drift-accumulations are of limited and local origin. Besides these loose flints, others are imbedded and cemented in a coarse silicious sand, forming masses of great solidity. These conglomerates or *Breccias* are like the pudding-stones, which characterise the Geology of Hertfordshire—excepting that those of the latter district are composed of water-worn flints. The Breccias are found scattered over and adjacent to the Chalk. In the villages of Portisham and Abbotsbury they lie about in great abundance, and at West Lulworth may be seen built into the walls on the main road leading from the Cove. Their bulk and indurated character prevented their dispersion during the changes which have swept lighter materials from the surface, and have since preserved them from destruction by human agency. Indeed, they are of such impenetrable hardness as only to be broken by some mechanical power. The flints which enter into the composition of these conglomerates were probably derived either from the Chalk, which once formed a continuous stratum over their present site, or they are the consolidated portions of the sand and sandstones of the Plastic Clay series; and it is evident how a current sufficient to dissolve and transport the soft matrix of either of these formations, and even equal to effect accumulations of loose flints, might be inadequate to the removal of such large masses.

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* 'Quart. Journ. Geol. Soc.,' vol. xxxi. p. 41.

† Ib., vol. xxxviii. p. 682.

SANDSTONE BOULDERS (DRUID STONES—GREY-WETHER STONES—SARSEN STONES*).

The wreck of former strata, probably coextensive with the Chalk, and similar to those of the Calcareous Grit; the sand, or other soft matrix in which they were imbedded, having been swept away by aqueous action. Though the Greywether Stones are of Tertiary origin, their isolated condition must be referred to diluvial † agency,

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* The presence of similar concretions on the opposite coast of France, in the cliffs ot St. Marguerite, near Dieppe, is so distinct as to leave little doubt that this is a prolongation of the same stratum which supplied the Druidical sandstone of Great Britain. 'Q. J. G. S.,' vol. ix. p. 129.

† Diluvial (from *diluvium*, deluge) is a term often indefinitely applied to deposits, supposed to have been formed by the waters of the general Deluge, such as marine shells, remote from the sea, or on elevated districts, blocks of stone detached from their parent beds and lodged far from their original sites, accumulations of loam and gravel, bones in caverns and fissures, &c.

At a later period, many of these conditions being traceable to other causes, beds of gravel and cave-bones were supposed to be the only visible effects of that great catastrophe. But subsequent investigations have determined even these to be of different ages. Though any Deluge must have produced considerable superficial changes, yet to define what these were involves a precision not attempted by modern Geologists. Diluvial agency is now restricted to those superficial deposits, whether of clay, gravel, boulders, or any other loose material, which could not have been formed or transported by causes now acting in the locality, such as violent floods, glacier-movements, icebergs, changes of level, &c., in contradistincacting during a geological period distinct from the present, though immediately preceding causes now in operation.

In Wilts these boulders constitute the large masses which form the trilithons or outer circles of the Druidical Temples at Stonehenge. In this neighbourhood they have been applied to similar purposes. Half a mile west of Winterbourne, on the road to Bridport, stands the remains of a British Temple, consisting of a circle formed of nine stones, enclosing an area thirty feet in diameter; and within a mile from this there are the remains of other temples: three miles west of Winterbourne, and one mile North of Abbotsbury, stands a Cromlech, the only one in the county. In a field adjoining the road from Weymouth to Osmington, near to the village of Little Maine, there is another cluster of Druid stones in sands, which rest immediately on the Chalk.* Besides these, insulated blocks of large dimensions appear in situations where it is difficult to suppose any mechanical power known to the ancient Britons could have placed them. One rests on the slope and near the top of the hill that overhangs the village of Portisham. Another still more remarkable example of such stones is afforded by the Agglestone near Studland (Isle of Purbeck), which is poised on a conical hill having a slope of 300 feet. The computed weight of this block is 400 tons, and it is said to have been regarded by the Danes as a "monument of Satanic malice."

Whence were these masses of stone derived? Referring to some in the neighbourhood of Pucknoll, Hutchins says, "The common people have a tradition, that the devil threw them from Portland," but elsewhere adds, "perhaps the stone might grow here." †

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tion to *alluvial* action. Alluvial (from *alluo*, to wash and add together) includes those deposits which result from causes now in operation, as the partial destruction of land by rivers, landslips, local floods, mountain torrents, growth of marsh-land, accumulation of sand-banks, mud and other deposits left by inundations. Dr. Buckland applied the term *diluvial* to the effects of the last great convulsion (the Noachian Deluge); *antediluvial* to the state of things immediately preceding it; and *post diluvial* or *alluvial* to that which succeeded it. Prof. E. Forbes restricts the term to deposits formed during the historic period.

* At the opening of the Deveril barrow, at Kimeridge, in the year 1826, several of these rude blocks were discovered in an erect position, placed in order, the largest measuring 13 by 7 feet.

† Hutchins, 'Hist. of Dorset,' vol. i. p. 218.

The geological theory adverted to in a previous chapter, removes any difficulty as to their origin, though it may be curious to know by what means stones of such magnitude were brought together, and in some instances raised several feet clear of the ground. These sandstone boulders must not be associated with *erratic* boulders, which have their origin in places far distant from their present site. An excellent collection of the fossils of Sweden has been made at Königsberg from the boulders which have been transported thither by glacial action.

RAISED BEACHES AND SHORE DÉBRIS.

The coast of Dorsetshire, like that of Devonshire and Cornwall, proves that the present shore has not been for any very lengthened time the boundary of the sea, but that within a comparatively recent period, the ancient coast-line has been elevated considerably above the existing high-water mark. This agency is probably still in operation, though only appreciable over a lapse of many centuries.* It is commonly said that the level of the sea has undergone a change, and not the solid parts of the earth. This, though it may appear to be the more simple solution of the question, involves in reality greater difficulties, as a rising or falling of the sea-level cannot be merely local, but must affect in the same degree the universal surface of the ocean.

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* On the European shores, the rise of coast is most remarkable on the sea-board of Sweden and Scandinavia; the former having risen to a height of 200 feet and the latter 600 feet. This rising has been estimated to take place at the rate of five feet in a century. At the head of the fiord of Udda Valla, 60 miles N. of Stockholm, the cliff now 40 to 50 feet above the level of the sea is composed of marine shells in mass of existing species; but the more remarkable accumulation is at Capell-backen, two miles inland, where, at an elevation of 200 or more feet, the mass of semi-fossil shells is perhaps unparalleled.

In an open space that may be compared to an amphitheatre, the sloping sides, which form a high bank, consist of bleached shells of species still living, though of a more northern character than those found in the adjacent sea. The quantity may be computed by millions of specimens, or by tons. The site of this deposit is little visited by travellers, some of whom consider they have seen in the Udda Valla Cliff the fossils referred to.

The supposition, that the area under consideration has, within a period not very remote from the present time, been subjected to an upward movement, is founded on the following evidences.

At the "Bill" or south end of the Isle of Portland, there is a consolidated beach or *breccia*, consisting of pebbles, broken stones, gravel, comminuted shells, and sand, united into one common mass by a stony calcareous cement. Though formed when these materials were on a level with the sea, it is now raised many feet above the reach of the highest tide.

The shingle composing this ancient beach differs but little from that of the existing Chesil Bank.

Crevices and ledges of the cliff on the same point of coast retain numerous shells of species now living in the neighbouring sea, lodged in their present recesses when that portion of the cliff remained within reach of the tidal wave. Portions of raised beaches on other parts of this coast might have been expected to occur, but for the circumstance that, with the exception of Portland, it everywhere consists of yielding strata, which the sea would cut through faster than the land rose.

Again, the presence of large irregular blocks lying beyond the line of the highest tides, containing the crypts of boring molluscs, not found in the stratum whence they were dislodged, but such as may be seen in rocks lying between high and low water on the shore beneath Bencleaves and on the north shore. It may here be observed that the cliffs behind the Chesil Bank could never have been exposed to the waves of the West Bay. An elevation of land here seems more than probable.

Weymouth, or rather that portion of it north of the harbour and known as Melcombe Regis, rests on beds of shingle, alternating with sand, with a substratum of Oxford Clay, to all appearance but recently raised to their present position, the highest part not exceeding eight feet above the level of the sea at high tide.*

Sir John Coode has shown that, on the north side of Weymouth, the shingle travels westward from Lulworth. The effect of this movement has been to accumulate a large beach between White Nore and Weymouth, which, like the shingle in the West Bay, has formed, between that town and Preston, a bar in front of the Lodmoor marshes. Further eastward, where the coast is no longer sheltered by Portland, the south-west winds resume their full effect, and the shingle its easterly movement.

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* In the great gale of November 1824, the site of Melcombe Regis was within a foot or two of being submerged.

Within the last few years, and probably owing to the Portland breakwater, the sand has lessened at "Smallmouth," and accumulated in Weymouth Bay, while the shingle on the Weymouth shore is travelling northwards in such quantities that ere long it may become necessary to bar its further progress by "groins," or other mechanical means. The south end of the Bay is also less affected by S. and S.E. winds.

Furthermore, the remains of an ancient sea-beach overspreads at intervals the bed of the Weymouth and Radipole Backwater, of which there is sufficient evidence in the quantity of stones collected for ballast and road-purposes. That they were drifted up the harbour channel appears improbable, and their being unlike those lodged by river action favours the supposition that this area was once open to the sea, and was subsequently closed by the rising of the strip of shingle on which Melcombe Regis is built. The pebbles of this ancient beach are chiefly calcareous, containing fewer flints than are found on the present shore, and to all appearance derived more from local materials. The grey stones of the neighbouring Cornbrash have supplied a portion. These rounded pebbles must not be confounded with the deposits of angular flints, also largely spread a few feet below the bed of the backwater, these being of a different epoch and derived from inland. The bluish-coloured clay just under the surface, full of the dead shells of *Scrobicularia piperata*, *Cardium edule*, &c., appears to be of Pleistocene origin, as the living shells are found at greater depths.

On the slopes of the valley at Preston, which terminates on the coast, there is a drift deposit of yellow loam, containing numerous land-shells of existing species, and in addition, marine species of kinds that are still being lodged on the adjacent shore. A section of the above deposit, which rests on the Calcareous Grit of the Coral Rag, may be very clearly seen in the cliff, as it rises on the east side of the valley to a height of from ten to twelve feet above high-water mark. The occurrence of land shells in the situation referred to may be accounted for by the river, which is now a mere stream, having once flowed to a greater height; but the presence of marine shells would seem to be due to the encroachments of the sea up the valley when the land stood at a lower level than at present. A bed of peat is at times exposed a little distance from the shore in Weymouth Bay, containing wings of beetles, tangled and partly carbonised plants, &c., which dries on exposure and burns like peat.

Numerous terraces, known as "Linchets" preserved on the hill-sides near and east of Upwey, as well as in other places within the Weymouth area, are considered by Mr. D. Mackintosh* to be raised sea-beaches, or sea-worn cliffs, dating from the time when this part of England lay beneath the ocean.

Mr. Poulett Scrope refers them to the wash of heavy rains, with river action, and the terraces themselves to the use of the plough when the slopes were under cultivation.†

LIST of SHELLS, &c., found in the Raised Beach on the east side of Portland, near the Bill, principally in yellow loam and sand.

UNIVALVES.

Buccinum undatum, L.
Lacuna puteolus, Turton.
Littorina obtusata, L.
  „ *rudis*, Maton.
  „ *litorea*, L.
Nassa incrassata, Mull.
Purpura lapillus, L.
Patella vulgata, L.
Rissoa parva, Da Costa.
  „ *var. interrupta.*
  „ *striata*, Ad.
  „ *subcylindrata*,‡ Jeff.
Skenea planorbis, Fabr.
Tectura virginea, Mull.
Trochus helicinus,‡ Fabr.
  „ *cinerarius*, L.
  „ *umbilicatus*, Mont.
Trophon (?)
Utriculus truncatulus, Brug.

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* 'Origin of Valleys, or the Sea against Rivers,' by Mr. D. Mackintosh, 'Geological Magazine,' 1866.

† 'On the Origin of Valleys,' by Mr. G. Poulett Scrope, ibid.

‡ With the exception of these two, all the above species are found now living in the adjacent sea. *Trochus helicinus* is a Northern species.

BIVALVES.

Anomia ephippium, L.
Cyamium minutum, Fabr.
Mytilus edulis, L.
Modiolaria marmorata, E. Forbes.
Ostrea edulis, L.
Saxicava rugosa, L.
„ *arctica.*
Tellina balthica, L.

SEA-WASTE—LANDSLIPS—ATMOSPHERIC INFLUENCES.

All such superficial changes which proceed under our daily observation or knowledge, and which, having been in operation during the historic period, are found associated with works of human fabrication, while in the more consolidated formations no traces of man or his productions have been hitherto observed.

The action of the sea on our coast, and the no less wasting process of land-springs, are important agents in wearing down and redistributing the solid parts of the earth. The rate of destruction is determined by the nature of the strata and various other causes. Where the cliff is composed of the older rocks, the waste is slow. In the Oolites, interstratified as they are with bands of softer clay and sand, it is more rapid, of which we have an illustration in the débris which fringes the Weymouth coast. The porous beds are permeated by water, which forces a passage towards the cliffs, carrying in its course the softer and more yielding portions. At Portland this action is attributable to the position of the Kimeridge Clay, which forms the substratum of the Island. The water passes through the numerous cracks which traverse the solid beds above and behind, and causes an undermining and consequent precipitation of the superincumbent mass. This was illustrated in the landslip of Dec. 26, 1858, when the sliding down of an extent of undercliff covering an area of twenty-five acres caused the sinking of an enormous mass of broken stone, the débris of adjoining quarries, and the accumulation of very many years. The scene of this occurrence was on the west side of the Island, overlooking the West Bay. In ascending from the beach shortly after the occurrence, the observer would be first attracted by the low undercliff of Kimeridge Clay, which, from lateral pressure, was pushed forward beyond the beach into the sea, and forced upwards with the shingle over it, so as to present a steep outer face towards the sea. A little way up the cliff a singular change was effected in the position of some garden plots, which previously inclined towards the sea at an angle of 45°, but dip now as much in the opposite direction, the plane of this portion of land having consequently traversed 90°, or one-fourth of the circle. The entire ground from the beach upwards was rent with innumerable cracks running in lines parallel to the coast, and rising in a series of steps or terraces. For many years the débris of the adjoining quarries had been thrown from trucks over the cliff, forming a kind of causeway extending some forty feet, all of which sank bodily down into basin-shaped cavities beneath, and carried with it portions of the main cliff. Either from the sudden withdrawal of this enormous mass, or the undermining which had gone on below, there was a partial severance of a large part of the solid cliff, which has left an open crack several inches in width.

The north-east side of the Island has been the scene of some extensive land-slips, some of which are recorded in Hutchins' 'History of Dorset.' *

2 Feb. 1615.—The pier was demolished; blocks that lay 40 yards off in the sea were risen above the water, and the ways leading from the pier to the quarries were turned upside down, and sunk in several places 30 feet. The earth for 100 yards slid into the sea. It was conjectured that this was occasioned by a great quantity of rubbish thrown over the cliff upon a clayish foundation, which, softened by the rain, gave way.

1694–5. Another occurred.

December 1734.—An exceedingly wet season. 150 yards of the N.E. end of the Island sank into the sea, by which a pier and road were destroyed, and the damage computed at 40,000*l.*

Feb. 13, 1792.—Another slide took place, more violent, more ruinous than either of the two former, of which a description is given by Francis Steward, Esq., Receiver-General of the land-tax for the county. At two o'clock P.M. the ground had sunk several feet, and was one continued motion, with no noise but such as was occasioned by the separation of the roots and brambles, and now and then a falling rock. At night it seemed to stop a little, but soon moved again, and before morning the land from the top of the cliff to the water-side had sunk 50 feet perpendicular. The extent of ground thus moved was one mile and a quarter N. to S. and 600 yards E. to W. One effect of these landslips is shown by the present position of the old burying-ground, which has been launched from the level of the land above into the valley seawards. The insulated condition of large portions of cliff near Pennsylvania Castle are due to the same cause.

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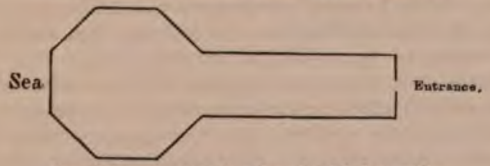
* Vol. ii. 2nd edition, p. 366.

The present site of Sandsfoot Castle marks the rapid waste of cliff where stony strata alternate with clay and sand. The library of the British Museum (King's Library, No. 18, D. 111) contains a map of Dorset, published in the year 1579, the oldest extant, in which this castle is placed not far from the centre of the field, and surrounded by a moat. The following is a ground plan of the castle as it then stood.

SANDEFFOOTE CASTLE in the 16th Century.



Parallelogram, 100 feet long by 50 feet wide.

FAULTS.

Wherever strata of different ages have been brought to the surface in a comparatively small area, those interruptions, technically termed faults, may be expected to occur.

If a particular stratum is traced to the face of a valley or break; on looking for its reappearance at the same level on the other side we may find one of different age. Thus in the "Craven" fault, which brings down the disjointed edges of the Silurian rocks on a level with the disjointed edges of the Coal Measures, the extent of the displacement is in places as much as 4000 feet, and the range of the fault exceeds 50 miles. (Prof. Prestwich.) In that case the cause of this is easy to understand. A subterranean movement has lifted the overlying strata, until (incapable of further flexure) it has become fractured and then raised in an unequal degree. This is further illustrated when the side or section of the raised portion is marked by grooves or deeply indented scratches, such as would be produced by the abrasion of the two surfaces under enormous pressure.* Faults are of different geological dates, as in some cases they reach to the surface, while in others the plane of the superior strata having been deposited after the fault, are undisturbed. In our district they throw all the beds to the Chalk inclusive, and therefore were formed subsequently to the deposition of that formation.

Ridgway Fault extends in a direction east to west, and can be traced from Ower Moigne to the sea at Abbotsbury; but it is probably of much greater length, as on the west it runs under the sea, and on the east into the Chalk. This fault Dr. Buckland names the "Great Ridgway Fault." Sir H. De la Beche conjectures that it is connected with the east and west dislocation which traverses the Isle of Wight,† and as this affects the Tertiary strata, the upheaval must have taken place in Tertiary or Post-tertiary times.

Dr. Fitton has in his map of the south-east of England, and of the coast of France,‡ marked the course of this fault as an anticlinal line from the coast at Abbotsbury to Swanage, from thence under the sea, crossing the Isle of Wight to Sandown Bay.

A fault of such magnitude involves the production of minor fractures, some in the same direction, others transversely to them; but the surface of the country having undergone numerous changes from denudation, landslips, &c., their existence is only made known by different beds of the same strata, or by strata of various ages being brought in contact. The main feature of the Ridgway fault is, that the Portland Stone has been raised relatively to the Chalk and Greensand, inasmuch as the Portland beds, belonging to a formation below the Chalk, is brought on a level with it—both dipping to the north, the Chalk being situated on the north side of the fault and the Portland Stone on the south. East of Moignes Down, the fault traverses a valley of denudation, the two sides of which are occupied by formations of different ages. At the top of the hill over the village of Bincombe, the Portland Stone and the Chalk are in contact. A little further to the north, the Kimeridge Clay and Greensand abut upon each other. At Upwey the Purbeck Beds on the south are on a level with the Chalk on the north. At Portisham the Kimeridge Clay is on the south, and the Chalk on the north; while at Abbotsbury the Coral Rag is found on the south side, and the Greensand on the north.

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* Opposite sides of a vein, or fissure, that are thus grooved and polished are known to the miners as slickensides. In the Appalachian Chain, on opposite sides of a crack over which a man can stride, beds are brought together that were once 20,000 feet apart. Professor Bonney, 'Geology' (Soc. P.C.K.), 1874, p. 43.

† 'Geol. Manual,' De la Beche, p. 168.

‡ 'Trans. Geol. Soc.,' 2nd series, vol. iv.

The position and course of many of these faults can only be traced by consulting the map of the Geological Survey (Sheet 17). The minuteness and accuracy with which the fractured strata of the district are there laid down by Mr. H. W. Bristow is a striking proof of the great care and labour bestowed by the officers of the Geological Survey upon their valuable publications.

Osmington Fault extends in an east and west direction, and is six miles in length. It emerges from the Chalk at Holworth and intersects the coast west of Osmington Mills, and again at Ham Cliff, whence it is represented on the map of the Geological Survey as running parallel to the great Ridgway fault. At Ringstead the effect of this disturbance has been to let down the Portland Stone into juxtaposition with the Kimeridge Clay.

At Ham Cliff the Coral Rag, on the south side of the fault, has been lowered to a level with the Oxford Clay on the north (see Fig. 27). Numerous other faults, coinciding in their course with those named, are shown in the map referred to; one extending from the village of Nottington, through Buckland Ripers, to the sea at the Fleet; and within a mile to the north another, parallel to this, passing through Holwell and Wyke Wood. It is only by the assistance of the map of the Geological Survey that these minor fractures can be traced.

Weymouth Saddle or Anticlinal.—This singular condition of the strata is exhibited in the arrangement of the beds lying between Weymouth and Upwey, where an anticlinal axis * forms a ridge in

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* Where strata are raised to form an arch and to dip on either side in opposite directions, like the two sides of the roof of a house, the line forming the upper part from which they diverge is called the anticlinal axis. Where the strata incline inwards from either side, the corresponding line is termed the synclinal axis.

The terms *dip* and *strike* refer to the departure of strata from their original horizontal position, and is made clear by the apt illustration of the roof of a house, or line of houses, in which the ridge and eaves represent the *strike* or direction of the strata, and the tiling on either side the *dip*, the Forest Marble,* on either side of which are laid in regular succession, or sequence, the zones or strata of the *Oxford Clay*, *Coral Rag*, *Kimeridge Clay*, and *Portland Stone* (see section in frontispiece); the direction of the strata being north-east to south-west. Thus, on the south side of the saddle reposes the Oxford Clay, crossing the peninsula of Weymouth, from Lodmoor to the shore at East Fleet, and succeeded by the Coral Rag, which with its subordinate beds forms another zone, extending from the Nothe, or jetty-point, to Wyke Regis; the Kimeridge Clay forming the substratum of the Island of Portland following, and lastly, the Portland Stone. This order of succession is repeated on the north side of the saddle, with the addition of the Purbeck beds, Wealden, Greensand, and Chalk.

QUATERNARY.

The various deposits grouped under the general term of "Post Tertiary" have been described in a memoir by Professor Prestwich, entitled "Notes on the Phenomena of the Quaternary Period in the Isle of Portland, and around Weymouth," which is accompanied with a map and numerous sections. This important contribution to the Geology of the district being published in the 'Quarterly Journal of the Geological Society,' it will only be necessary to make a brief reference to its contents.†

It has been already observed that there are drift deposits, at various levels, in numerous places around Weymouth, composed of gravel, pebbles, and chalk-flints, and in some spots containing the remains of Elephants. The most remarkable of these is that of Portland, where in quarries at the Verne, or north end of the Island, and at a height of 400 feet above the sea-level, remains of *Elephas primigenius* and *Elephas antiquus* have been found. This mammaliferous drift contains, besides angular local débris, small blocks of Sarsen Stones, water-worn pebbles of chert from the Upper Greensand, and fragments of flints, none of which occur *in situ* in the

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which must necessarily be at right angles to the direction of the strike. Perfectly horizontal strata are without either dip or strike.

* The Forest Marble (though in stratigraphical order it is the lowest of the Weymouth strata) has been raised to the surface, and forms the central stratum.

† Vol. xxxi. p. 29 (1875).

Island, but may be traced to the hills between Upwey and Dorchester, from which Portland is now separated by the Bay of Weymouth, and low plains of older (Jurassic) strata. As with a magician's wand this intermediate space has been bridged over. "If," writes Prof. Prestwich, "the dip of the Portland and Purbeck beds at Portland be prolonged northward, they would reach an elevation of about 1000 feet at Broadway, and of about 1500 feet at the Ridgway. . . . Carrying our view back to the latter part of the Glacial Period, before the present valley-systems or even some of our plains were elaborated, a broad tract of Chalk, bounded in places by Greensand, and capped by Tertiary beds and older gravels, rose inland; and with these the Purbeck and Portland beds were brought into level juxtaposition by and along the great line of fault running westward and eastward nearly midway between Dorchester and Weymouth. From that district the surface of the country sloped gradually to the south end of Portland; and over the surface, which then bridged over the plain of Weymouth, streams, originating in the Chalk, Greensand, and Tertiary district, flowed southward to the Channel. It was one of these streams which, passing over Portland, rolled down to that island pebbles derived from those several newer formations, while the floods and ice of winter carried down the larger Sarsen-stone boulders also so common in the same fluviatile bed, and entombed the remains of the elephant, horse, &c., then living in that area" (p. 51).

In the same Paper other questions are discussed relating to those Geological changes which have given rise to the present coast-line and other diversified features of the district.

RECENT PERIOD.

SHELL MOUNDS AND KITCHEN MIDDENS.

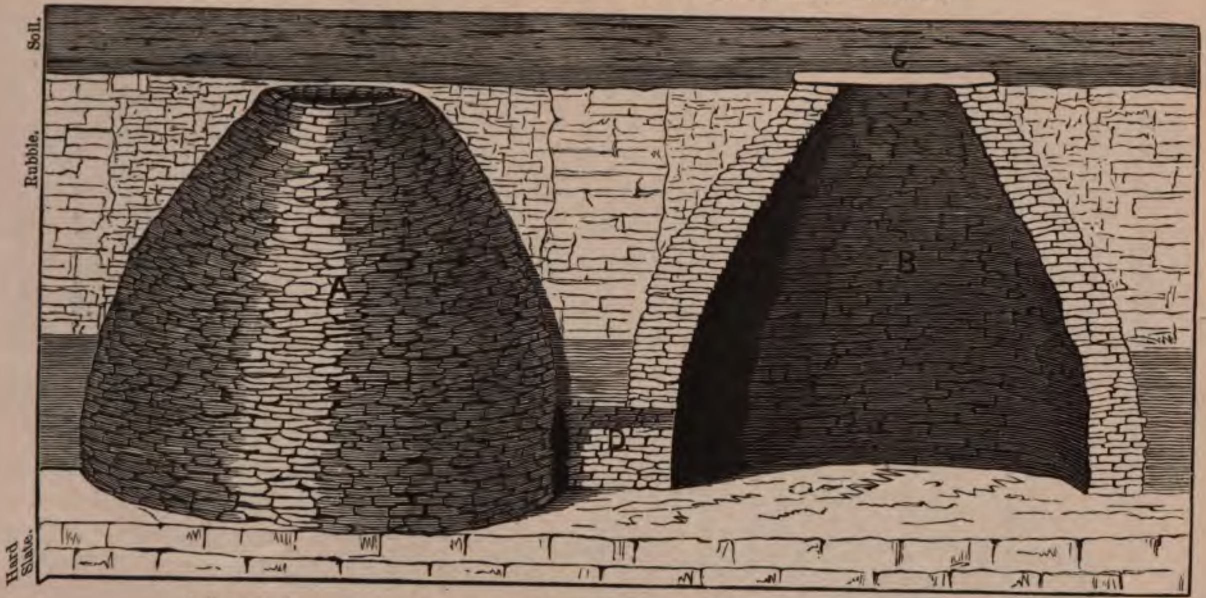
As the older strata pass into the succeeding, so does the later or more recent formation pass into those of the "prehistoric" and "historic periods"; thus does Geology blend with Anthropology and Archæology, the line of separation being rarely definable. On the shores around the Baltic, and especially in Denmark, are numerous sunken hut-circles in which are found the remains of wild and domesticated animals, fish-bones, castaway shells, coarse pottery, mealing-stones, &c. To these early accumulations Sir John Lubbock has given the name of Neolithic, in contradistinction to the more ancient or Palæolithic age. Middens are not, however, confined to the Baltic shores, but are met with in different parts of England, and the Continent; they are usually near the sea-shore, marking the site of an ancient encampment, it may be for fishing purposes, or as points of observation. On the Chesil Bank, between Sandsfoot Castle and the Ferry Bridge, are the sites of one or more which contained castaway shells of edible species, fish- and other bones, charcoal, hand-made pottery, and other refuse products of a semi-barbarous people. Another such circle was exposed a few years since on the south side of the Nothe promontory; and Mr. Warne refers to one on the slope of Jordan Hill. Doubtless the sites of others exist along this coast of which no account has been taken.

UNDERGROUND HUTS (Dene-holes).

Recently there have been discovered in quarries at Kingbarrow in the Isle of Portland, underground structures of beehive form that may be classed among the most remarkable remains of the manners and customs of an ancient people hitherto found in Dorsetshire.

Mr. A. M. Wallis, Quarryman and Guide, to whom I am indebted for much local information, first observed them in the year 1880; but since then others have been uncovered, and he reckons that not less than twelve have already passed under his observation, all found within an area of less than half a mile. Quarrying operations would not allow of their being preserved, though at the present time (May 1884) the sections of four are still visible. In all probability others will be exposed as new ground is broken, when it is hoped that an attempt will be made to preserve, for a time at least, one or more of these interesting structures. As already stated, they are of beehive shape and in height 8 feet, with a width at bottom of from 10 to 12 feet. They are completely walled in with flat stones overlapping inwards, until they leave an opening at the crown, of 16 inches diameter, which opening is generally found covered with a slab: over all is the soil of about a foot in thickness. One, and only one, was 12 feet deep, and therefore penetrated several feet into the hard slate beneath. But the most remarkable is one of a twin structure, the external and internal view of which is given in the accompanying sketch, a singular feature being a passage at the base between the two, of 2 feet in height by 2 feet 6 inches in width.

Fig. 56.—Twin Underground Huts, Kingbarrow, Isle of Portland.



A External view. **B** Inner section. Height 8 feet, width at bottom 10 feet. **C** Opening at top, 16 inches. **D** Passage at base from **A** to **B**, 2 feet × 2 feet 6 inches.

Taking the whole of the huts, the following objects have been found in them :—

Skulls and bones of domestic animals. Numerous.

Limpet Shells (*Patella vulgata*). Some in sets of graduated sizes. Numerous.

"Corn-crushers," rounded, hard, grey stones, used for bruising corn. Numerous.

Sling-Stones ? Numerous.

One Celt, and small flint-flakes.

Flint Pebbles, apparently from the Chesil Bank.

Pieces of Kimeridge Shale.

Pieces of hard, grey stone (not Portlandian), from which the "Corn-crushers" appear to have been made.

Blackened Wheat. In one hut a quantity equal, my informant says, to a wheelbarrow-full.

Outside the huts several mortar- or mealing-stones were found; and an old iron sword has been shown as from the interior, but this statement was from a workman who classed all holes alike, and I have no hesitation in referring it to one of the oblong graves, found in the vicinity, that contain human skeletons, personal ornaments, pottery, and other remains of more recent date. Some of the articles from the huts do not differ from those found in the Swiss Lake-dwellings.

The Portland huts may be said to resemble in many particulars the underground dwellings of the North of Scotland known as "weems" and others as "beehive houses," which are supposed to have existed as far back as the "Stone age," though they are also known to have been inhabited down to the year 1823.*

Dr. E. B. Tylor quotes Tacitus for a description of caves dug by the ancient Germans, and heaped over with dirt, or growing turf; where they stored their grain and took refuge themselves from the cold, and at times from their enemies.†

Sir J. Lubbock describes many forms of these ancient dwellings in which the only entrance was through the roof, and when concealment was an object the rooms were subterranean.‡

That such structures were in part used as granaries, appears highly probable.

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* Wilson, 'Prehistoric Annals of Scotland,' vol. i. p. 104.

† Dr. E. B. Tylor, 'Anthropology,' chap. ix. p. 232.

‡ Sir John Lubbock, 'Prehistoric Times,' 1869, chap. ii.

CHESIL BANK.

The Chesil Bank, situated within one of the largest bays in the kingdom, is the most remarkable formation of its kind. Its magnitude exceeds that of any other in Europe,[*] and it may fairly rank in interest with the mountain chains and other monuments of physical geography. It connects the Isle of Portland with the mainland at Abbotsbury (a distance of 10¾ miles), from which place it extends along the shore, rapidly diminishing in extent, to Burton Cliff, 16 miles west of Portland. Its breadth at ordinary low-tides was computed by Sir John Coode,[†] to be 200 yards, and its height to be 42 feet above high-water; and at Abbotsbury 170 yards wide and 22 feet 9 inches high. At Portland it extends to a depth below high-water of 48 feet, and at Abbotsbury of 36 feet. Proceeding westward the depth under the sea decreases at Burton Cliff to 21 feet, and at Bridport Harbour to a depth of only 9 feet.

The size of the pebbles, as a mass, increases in a direction from west to east, being west of Abbotsbury but little larger than coarse gravel,[‡] and at Portland from 1 to 3 inches in diameter, with occasionally some of still larger dimensions.

But to this there are the following exceptions, viz., that the pebbles diminish in size as the bank nears the Isle of Portland; also, that stones as large as those at Portland are to be seen on other parts of the bank where the wind-wave has been most intense; but even these are more plentiful towards Portland. It will also be observed that the larger pebbles are flattened, as though they had been pushed forward rather than rolled. Camden,

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[*] A raised mass of shingle, the largest probably in the world, is described by Darwin as extending from near the Rio Colorado to a distance of 700 nautical miles, with an average breadth of 200 miles, and a depth of 50 feet.—Darwin's 'Journal of Researches,' p. 171.

[†] A description of the Chesil Bank, by Sir John Coode, M.Inst.C.E., was read at the Institution of Civil Engineers, May 3, 1853. This Paper contains much original information founded on lengthened observation.

[‡] East of Bridport Harbour the beach is curiously sorted, a large quantity being sufficiently fine to be used for stone-cutting. On the west side it is again larger. The piling of the Harbour, which extends some distance from the shore, acts as a groyn, causing the larger pebbles to bank up.

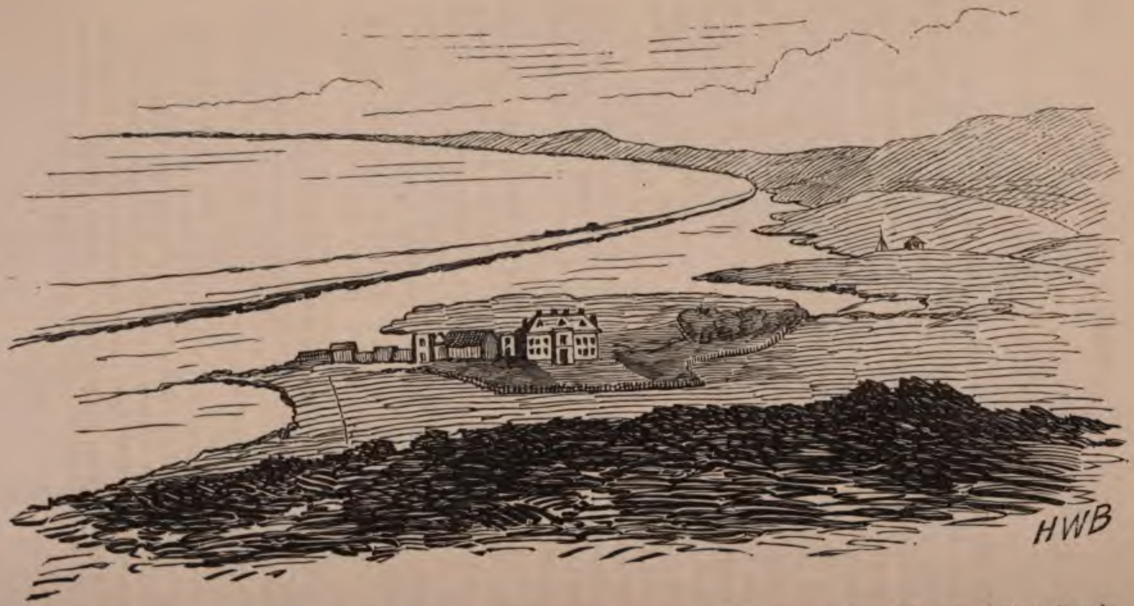

FIG. 57.—VIEW OF THE CHESIL BANK AND THE "FLEET" OR "BACKWATER" (looking westward from near Fleet House).

Leland,* and Holingsworth say that Portland was once an Island. This could scarcely have been its condition within the historical

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* Leland gives us this particular account of the island and its environs in his time :—

"This arm (viz. that runneth up by the right hand of Waymouth Haven, to Portland Passage; see Waymouth) going up from the Strait of Trajictus, and is of good bredth, and so se goith up to Abbates-Byri, about a vij. miles of, where is a litle fresh water resorting to the se. A little above Abbates-Byri is the head or point of the Chisil, lying North Weste, that from thens streach up 7 miles, as a maine narow banke by a right line on to South Est and ther buttith on Portland, scant a quarter of a mile above the new castell in Portland. The nature of this bank of Chisil is such, that as often as the wind blowith strene (f. strong) at South Est so often the se betith it, and losith the bank, and breakith through it. So that if this might continually blow there, this bank should soon be beaten away and the se fully enter and devide Portland, making it an isle, as surely in tymes past it hath beene, as far as I can by any conjecture gather. But as much as the South Est wind dooth bete and breke off this Chisille bank, so much doth the North West wynd again socor, strength and augmentith. On the farther point of the Trajictus into Portland, comming from Waymouth, is a point of land like a causey al of pible and sand, cast up by the rages of the se. Wheron I went scant a mile, to the lowest part of the rotes of the high ground of Portland, wher a late a right strong and magnificent castel is buildid at this causey end. And from this castelle to the very South Est point of the Chisil, is but a little way: and the arme of the se that goith up to Abbates-Byri, gulfith in bytwixt the South Est point of the Chisil and the castelle.

"Portland has been of auncient tyme, by all likelihod environid with the se, and yet berith the name of an isle. It is eminent and hilly ground on the shore of it and a great plain in the midle of it. The cumpace of it is countid to be about a 7 miles. But if a man should cumpace it by the very rootes, and depe shore would mount to a 10 miles. The soil is somewhat stony; and the shore very rokky.

"The isle is fruiteful of corn and gresse and hath plenty of sheepe. Ther be at this present tyme about a 80 housis in the isle.

"Ther hath been almost as many mo, as it apperith by the ruines. Ther is but one streat of houses, in the isle the residew be sparkelid. Ther is a castelet or pile not far from (the) streate, and is set on a high rokke, hard by the se cliffes, a little above the Est end of the cherch. The paroche cherch, that is but one at this tyme in the isle, is longe, and sumwhat low buildid in the hangging roots of an hill by the shore. This cherch and paroche is about a mile *dim*—to go the next way to it from the Kinges new castelle, in the isle; and to go to it by cumpace of the shore it period, though at one time it was probably separated from the mainland. The blue clay on which the shingle has accumulated having been a reef or shallow bank, served to arrest the pebbles, which, but for this obstruction, would have been driven farther to leeward.

The Chesil Bank is an example of the sea producing a barrier to its own progress—the destruction of one part of the coast becoming the means of protection to another portion. It effectually checks the heavy waves of the Atlantic, which would otherwise encroach on the land behind and probably sweep away the shingle on which Melcombe is built.

The Fleet, a narrow arm of the sea that separates the Chesil Bank from the mainland, is the necessary result of a bar thus thrown up, which, by preventing the escape of land-springs from the shore behind, forms an inner channel, the level of which with the outer sea is preserved by the surplus water percolating through the shingle. Weeds, on a flat shore, are not unfrequently thrown up in the form of a ridge, leaving a lagoon or inner belt of water on the land side.

In a short paper, contributed to the 'Geological Magazine' (Oct. 1869) by Messrs. Bristow and Whitaker, the existence of the Fleet is thus explained.* Originally the Chesil Bank was beached up against the land; the streams from which, having a tendency to flow southwards on reaching the coast, wore away the land behind

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is 3 miles, or more. Sum say that in tymes past, ther was another paroche chirch in the isle; but I there lernid no certente of it. There be very few or utterly no trees in the isle, saving the elmes about the chirch. There wold grow more, if they were ther plantid; yet is the isle very bleke. The people bring wood thither, out of Wight and other places. They brenne also cowe dung dryed with the hete of the sunne. The people of the isle lyve most now by tillage, and sumwhat faulle from fishing.

"The people be good there in slyngging of stonys, and use it for defence of the isle. The people ther be politique inough in selling their commodities, and sumwhat avaritiose. The personage sette in the high streat is the best building in the isle. The bishop of Winchester is patrone of the chirch. The isle is the Kinges; and much of the land there is holden by . . . . of hym."—Leland's 'Itinerary,' vol. iii. pp. 66, 67.

* The woodcut from this Paper (Fig. 57), from a sketch taken by Mr. Bristow, has been obligingly lent by Dr. H. Woodward, F.R.S., Editor of the 'Geological Magazine.'

the beach, and made an outlet for the combined streams. Where there is no stream the beach remains united to the land. Ancient maps show the Fleet to have been much wider than at present.

Whence is this mass of shingle derived? From the bottom of the sea-offing? Trawlers who dredge the West Bay report it to be free from pebbles. From Portland? That would imply that they travelled against the prevailing winds, in a direction contrary to that of the waves; moreover, with the exception of some portions of flint, the Portland beds are calcareous, while the pebbles of the Chesil Bank are chiefly silicious.* The materials forming shingle beaches, which in most instances are derived from cliffs at no very remote distance, travel in a given direction. On both sides of the Channel this is from west to east,† and is the result of the preponderance of south-westerly winds, both as regards their duration and force. If a groyn or other projection is erected on the south or south-east coast, the accumulation of shingle is on the west side of such a barrier.‡ To effect this result it is not necessary that the prevailing winds should blow in a direction parallel to the coast; any wind which strikes it, however obliquely, will exert a force tending to impel the shingle in the same direction.

Of the pebbles composing the Chesil Bank chalk-flints are the most numerous. A white semi-transparent quartz is identical with certain unrolled flints found in the valleys of Chideock and Charmouth. Others have been traced to the Cretaceous Beds between Lyme and Sidmouth; some, of a different character, to Budleigh-Salterton, and others to Aylesbere Hill, whence they were brought down to the coast by the River Otter. The sandstone and older rocks of Devon have supplied porphyry and variously-coloured jaspers; and the wrecks of vessels may have contributed other varieties. Though these data indicate the sources whence certain portions of the beach have been derived, the rate of supply from them is not sufficient to account for the formation of a deposit of such magnitude. The sea produces little effect on older rocks; the Chalk which furnishes the flint is of a more yielding nature; but even there the waste of cliff is comparatively inconsiderable—scarcely more than sufficient to supply flints enough to make good the loss occasioned by attrition and removal.

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* Silicious pebbles are so hard and crystalline that the point of a knife makes no impression on them, while marbles and other forms of limestone yield to that test. Sulphate of lime (Selenite, Gypsum, &c.) is sufficiently soft to be scratched with the nail.

† It deserves notice that the *raised beaches* at the entrance into Torbay —at Slapton, and on the coast of Cornwall, as well as those on the other side of the Channel, around Cherbourg and the Channel Islands, indicate that their materials while in process of accumulation travelled in a direction from East to West, the reverse of the present movement. See R. A. C. Godwin-Austen, 'Quart. Journ. Geol. Soc.,' vol. vi. p. 69, and vol. vii. p. 118.

‡ 'On Sea Beaches,' 'Philosophical Transactions,' 1834, p. 568.

If causes now in operation are admitted to be inadequate, and we are to look for other agencies, the view taken by Dr. Buckland appears not improbable. He supposes that the diluvial waters which excavated the extensive valleys intersecting the coast at Abbotsbury, Chideock, Charmouth, &c., swept their materials into the bed of the British Channel, whence they have been drifted into their present positions by the influence of the prevailing winds blowing from the south-west.*

It has been noticed that the largest pebbles are towards Portland, the leeward extremity of the Bank. Had the reverse been the case, possibly the fact would not have been discussed, as it might be supposed that the smallest pebbles would travel farthest, or that those which had travelled farthest would be worn down to the smallest size. Some consider this circumstance to be due to the tidal action of the sea, others to the velocity of the waves, increasing gradually from the south-west to the north-east (the direction of the beach), and therefore that the size of the pebbles thrown up would be the largest where the force of the sea was greatest. Sir John Coode is of opinion that large pebbles, from offering a larger surface to the power of the water, are more easily moved than smaller ones. Their occurrence at the summit of the Bank results from the force of the advancing wave being greater than that of the retiring wave, in the same manner as on a sandy shore the heavier substances may be observed to be thrown up the farthest, because the wave by which they were lodged, in consequence of being dispersed or divided into spray, returns to the sea with diminished force.†

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* 'Reliquiæ Diluvianæ,' p. 246.

† If two corks, one of which is weighted to sink to the bottom, be thrown into the sea, the floating piece keeps its distance from the shore, while the weighted one will be thrown upon the beach.—Godwin-Austen, 'Quart. Journ. Geol. Soc.,' vol. vi. p. 75.

The position of the shingle lying within reach of the waves undergoes considerable modification according to the direction and force of the sea, the motion thus imparted to the shingle being either a destructive, an accumulative, or a progressive action. As an illustration, Mr. Palmer watched at Dover, during a gale of wind, the rate of succession which exhibited the destructive and accumulative action in their smallest degree, and observed that when ten breakers arrived in one minute, the destructive action was but just evinced, and that when only eight breakers arrived in the same period, the pebbles began to accumulate; which harmonised with other observations he made elsewhere.* Sir J. Coode considers "seven or any less number of waves per minute as inducing the destructive action, and nine or any greater number in the same time the accumulative action."

During a strong S. to S.S.W. gale the waves rolling in from the Atlantic are of such magnitude and force as is seldom witnessed on other parts of the coast. It is stated that in the gale of November 23, 1824, a sea-going ship was by the force of the waves lifted over the Chesil Bank from the West into the East Bay. The facts which came under my own observation were these: The sloop 'Ebenezer,' of about 50 tons, was driven high up on the Bank, and afterwards drawn over by channelling the Beach to the other side.

Since the publication of Sir John Coode's paper others have been written on the subject in various scientific journals, of which the most important is that by Prof. Prestwich, entitled "On the Origin of the Chesil Bank, and on the Relation of the existing Beaches to past Geological Changes independent of the present Coast Action" ('Proc. Inst. Civ. Engineers,' vol. xl. p. 61, 1875). The Authors of the various papers referred to agree in the main with the views held by Sir John Coode, but the increased attention which has been given to the Raised Beach at Portland Bill, introduced a new element in the discussion. "At a distance of 25 miles south of the Chesil Bank, and parallel with it, is the contour line of 30 fathoms, and the line of 20 fathoms passes within 6 miles of the Bank, and only 1 mile from the south end of Portland, while the line of 15 fathoms extends to within a mile of the shore off the northern portion of the Chesil Bank.

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* 'Philosophical Transactions,' 1834, p. 271.

This leads, during storms, to the inset of a very heavy ground-swell, and causes the waves to break on the Bank with great violence" (p. 75). The probability of this ancient Raised Beach extending from Portland Bill to Torquay and Dartmouth being conceded, Prof. Prestwich considers that the Chesil Bank was formed from shingle derived in part from the Southern end of Portland, but mainly from the submerged portion of the beach spread over the sea-bed of the West Bay, adding "that in this ancient beach there was a store amply sufficient." Further that this shingle is "deflected northwards by the influence of the Race, and thrown up during storms on the south end of the Chesil Bank," where, exposed to the prevalent wind-waves from the south and south-west, it gradually travels towards Bridport. "To the great accumulative power, and small propelling power thus exercised the large dimensions of the Bank and the great wear of the shingle, as it slowly travels from Chesilton to Abbotsbury, are probably due."

Prof. Prestwich's conclusions are summed up in the following propositions:—

1st. That the shingle of the Chesil Bank is chiefly derived from the materials of the "raised beach," of which a remnant still exists *in situ* on the Bill of Portland, and partly from the harder beds of the Portland and Purbeck formations of that island.

2nd. That the storm-waves, in conjunction with the tidal current, drive the shingle of the old beach from the bed of the Channel on to the southern end of the Chesil Bank, whence it travels by the agency of wind-waves in a north-westerly direction towards Bridport Harbour, at the other side of which the shingle travels in the opposite direction, or from west to east.

3rd. That the growth of the Chesil Bank has been from south-east to north-west, under the influence of the two above-named forces.

4th. That the shingle of the "raised beach" itself was formed of materials which had travelled direct from the coasts of Devonshire and the adjacent parts of Dorset, eastward to Portland.

The discussion of this paper, which occupied the whole of three evenings, was sustained by the Author, Sir John Coode, the Astronomer Royal, and other distinguished members of the Institution, and excited considerable interest.

Adversely to these conclusions, Sir John Coode observed, that "One important point had come under his observation a few years since, viz., the tremendous transporting power which came into play upon the shingle on the long stretch of beach between Bridport and Portland during the prevalence of the heavy surf, following the subsidence of S.W. gales. By a series of observations in the locality, extending over several years, he had ascertained that of every eleven heavy S.W. gales, ten terminated by the wind 'flying up' rapidly by W. to N.W. and N.N.W., and then subsiding. This state of things always resulted in the changing of the direction of the breakers near the shore, and so deflecting them in a distinct south-easterly direction, as to drive the shingle along the coast from Bridport and Burton towards Portland."

The many curious relics that have, at various times, been here thrown up from the sea, invest the Chesil Bank with an antiquarian interest. Coins of gold, silver, and copper, of ancient, mediæval, and modern date, are of frequent occurrence. Of ancient coins, those of the Roman Empire are the most numerous, especially the "third brasses" of Constantine. The occasion of their being found is only after a continuance of ground-seas, when the waves, receding in rapid succession, produce a downward current, scouring away the shingle and exposing the blue clay (Kimeridge) beneath. During the prevalence of a ground-swell there is but little wind, and the waves approach the shore at, or nearly at, right angles. At times the ground-sea continues for several days, when the shore is thronged with persons searching the clay exposed by the receding waves. On such occasions coins have been collected, and rarely, antique rings, and seals, plate, silver, and even gold ingots,* with other relics which have survived the destruction of vessels wrecked on the beach of this much-dreaded bay, and offering melancholy and singular evidence that the mariners of ancient as well as modern nations have here alike found a watery grave. A winter rarely passes without the Chesil Beach being the scene of some disaster.* A change of wind or turn of tide restores the shingle to its place, and covers this storehouse up again.

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* Almost realising the dream of the Duke of Clarence:—

"Methought I saw a thousand fearful wrecks;
A thousand men that fishes gnaw'd upon;
Wedges of gold, great anchors, heaps of pearl,
Inestimable stones, unvalued jewels,
All scatter'd in the bottom of the sea.
Some lay in dead men's skulls; and in those holes
Where eyes did once inhabit, there were crept,
As 't were, in scorn of eyes, reflecting gems,
That woo'd the slimy bottom of the deep,
And mock'd the dead bones that lay scatter'd by."

High up on the Bank after a storm may be collected many of the deep-water kinds of Zoophytes, Corallines, Algæ, viz.:—

Antenularia, *Gorgonia*, *Plumularia*, *Sertularia*, *Tubularia*, *Scalpellum vulgare* (rare), *Lepas anatifera* (common Barnacle) in masses, *Lepas anatifera* and *L. fasicularis.* It is the only known habitat on the British Coast of an elegant species of Cirripedia—*Acasta Montagui*, found nestled in sponge. Capsules of *Buccinum undatum* (Whelk), and numerous ovaries of Fishes, seed-vessels, and other vegetable products of the West Indies and Northern America are drifted across the Atlantic and are found on the shore.

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* A Spanish Galleon was known to have gone down many years ago near Chesilton.

Nov. 1795.—A fleet under Admiral Christian, endeavouring to reach Torbay, encountered a gale in the West Bay, which drove a large number of transports on shore, when 1000 persons were supposed to have perished.

March 27, 1815.—The 'Alexander,' from Bombay to London, with passengers and troops, was during the night driven on the beach opposite the village of Wyke, and all on board perished, excepting four lascars and one woman.

Nov. 23, 1824.—During this memorable gale, a large number of vessels were embayed and lost.

Oct. 1839.—In a gale of great violence, nine vessels foundered or were driven on the beach between Portland and Abbotsbury, with the loss of all on board, excepting one ship of 500 tons which was thrown in on the top of a wave high on the bank.

Nov. 25, 1872.—The 'Royal Adelaide,' a new iron ship, with passengers for Sydney, was wrecked on the beach near the Ferry Bridge. For the first time, the rocket apparatus was successfully applied, under the direction of Capt. R. V. Hamilton, of H.M.S. 'Achilles,' all but twelve persons being rescued. The gale was one of great violence. The noise of the breakers and that of the recoiling shingle made it impossible to carry on conversation. Being night increased the confusion. Tar-barrels were ignited to illumine the shore and give hope to those on the wreck, to whom the scene was, as described by the survivors, one of great terror.

A crowd had assembled on the beach whose uplifted faces were made visible by the weird light of the flaming casks, added to which was the excitement when the basket returned for its living freight. The dread of being first pulled through the successive seas that rolled from the wreck to the shore, made many prefer to meet their end rather than encounter so terrible an ordeal.

A large quantity of watches, jewellery, and plate was on board as cargo, and passengers' baggage, but how much of this has been recovered will never transpire, as persons known to have such property in their possession would either be dispossessed of it or brought under the conditions of recent legislation. A portion of the ship's framework still remains submerged, where it interferes with fishing-operations.

During the fishing-season some of the rarer and exotic species of fishes are captured, among which the following may be named:—

Balœnoptera rostrata. (Fin Whale.)
Squalus glaucus, L. (Blue Shark.)
Carcharias vulpes, Cuv. (Thrasher.)
Squatina angelus, Dum. (Monk-Fish—Angel-Fish.)
Torpedo vulgaris, Yarrel. (Electric Ray.)
Thynnus thynnus, L. (Tunny.)
Orthagoniscus mola, Günther. (Sun Fish.)
Cyclopterus lumpus, Günther. (Lump Fish.)
Capros sanglier, Günther. (Boar Fish.)
Lophius piscatorius, Günther. (Angler, Fishing Frog, or Sea Devil.)*

The Bank is from various causes both exciting and attractive. During a gale from south to south-west, waves from the Atlantic are here arrested, and break with such force that no ship, receiving them broadside, could escape destruction. If the gale should suddenly cease a ground-sea follows, when the whole line of beach within reach of the waves is set in motion with a recoiling action of the pebbles, the grinding of which produces a loud rumbling noise that can be heard many miles distant. In calm weather the Bay wears the opposite aspect, as then only a gentle ripple falls on the shore.

Portland, like many other isolated spots, has a fauna and flora of its own. "Of the 510 recorded species of spiders known to inhabit

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* Hutchins makes a curious contribution to the Natural History of the Chesil Beach:—

"June 1757, a *mermaid* was thrown up on the shore between Portland and Burton, thirteen feet long. The upper part of it had some resemblance to the human form, the lower was like that of a fish; the head was partly like that of a man, and partly like that of a hog. Its fins resembled hands; it had forty-eight large teeth in each jaw, not unlike those in the jaw-bone of a man."—'History of Dorset,' vol. i. p. 338, 1st edition, 1774.

Great Britain and Ireland, 382 have been found in Dorsetshire, of which number 17 are peculiar to the Isle of Portland—so far at least as Great Britain is concerned—and of these three have not as yet been found anywhere else."—'Spiders of Dorset,' by the Rev. O. Pickard Cambridge, M.A., &c.

In the "List of the Lepidoptera of Portland,"* by C. W. Dale, Esq., 280 species are enumerated, many of which are rare in Britain, and some hitherto not found out of the Island.

In addition to the catalogue of Plants peculiar to Portland and the Chesil Bank, I have it on the authority of Sir W. C. Medlycott that it has several kinds of Mosses and Lichens that are not recorded as from any other part of Great Britain.

AGATES.

A description of the Chesil Bank would be incomplete without some account of the constituent character of the pebbles of which it is composed, especially as stones other than those found on the Bank are reputed to be such. As already stated, variously-coloured flints from the neighbouring cretaceous beds form the bulk of the deposit, added to which there is a sprinkling of Jaspers, Moss Agates, Corals, and Madrepores of the Devonian and older rocks, but which are scarce towards Portland.

The Agates so largely sold in this country of late years are chiefly derived from South America, though frequently referred to the localities where they are offered for sale. Thus, pebbles taken from the sea-shore at our watering places, as well as in certain mountain districts, are, if taken to some lapidaries, metamorphosed into Topazes, Onyxes, &c.† A brief history of the Agate trade may not therefore be considered out of place.

At Oberstein, a small picturesque German town near Saarbrück, recognised from the railway by a little church cut out of the rock in the face of a precipice, is a centre of this modern industry. The region in which it is situated consists chiefly of mountain masses of amygdaloidal Melaphyres, traversed by fissures, containing Agate and Amethyst-geodes—at one time in great abundance. These, however, failing near the surface, roadways constructed to reach greater depths were employed; but the supply from this source has now ceased.[*]

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* 'Proc. Nat. Hist. Soc. of Dorset,' vol. for 1877, p. 53.

† This is not intended to apply to the moss-agates and other beautiful stones found on many parts of the English Coast, and in Scotland.

Being favoured, also, with water-power derived from the surrounding hills, the cutting and polishing of the Oberstein Agates became in the fifteenth century the amusement of the resident nobility, which within the present century has developed into a large and important trade. A few years since, it was feared that the rapid exhaustion of the raw material would bring the industry to a close. At this crisis the trading community of Oberstein, and Idar, the adjoining and now the more important town of the two, despatched a scientific expedition, which, after a lengthened search, found in Paraguay Agate-geodes suited to their purpose in such abundance as to be shipped for ballast. These are now imported and sold by auction in Idar at prices ranging from 1*l.* to nearly 100*l.* per cwt. Some are in the form of geodes and others of stalactitic chalcedony, a variety of milk-white quartz deposited in layers or bands, which, being more or less absorbent, assume under chemical treatment a dark-brown or chocolate colour, while others take up the red tints of carnelian; and in the most valued stones, where the layers are strongly contrasted, the effect is to produce alternate black and white bands resembling those of the onyx. The colouring is effected by the agates being first soaked in oil, and then in sulphuric acid, which carbonises the oil, and leaves the laminæ that are most cellular brown or black. The intensity of the blackness depends upon the quantity of carbon absorbed. Honey, or a syrup of sugar, is sometimes employed as a substitute for oil. To produce the red colour of the carnelian a preparation of iron is used, and for the imitation of lapis lazuli two or three processes are employed, one being the use of an ammoniacal sulphate of copper. Of late years numerous other tints have been produced.

Whatever imposition may be practised in the sale of agate articles out of the country, there is none on the part of the lapidaries and merchants of Oberstein and Idar, than whom there is not a more honourable class. The artificially coloured stones are sold as such, and for the purposes to which they are applied are not considered to be of less value. Agate articles that are here produced in countless numbers find a market in all parts of the world. Nearly the whole of the male population are engaged in the various operations that arise out of the trade, to which cameo-cutting has, since the war with France, been added. The prosperity of the industry thus developed may be seen in the superior class of houses and the air of respectability that prevails in Idar, where the polishing-mills are situated, and the principal merchants reside.*

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[*] An excellent account of the Agates and Agate Workings of Oberstein was given by Mr. F. W. Rudler, in 'Pop. Sci. Rev.,' N. S., vol. i. p. 23. 1876.

Referring to the modern practice of colouring Agates artificially, the late Prof. Nöggerath, of Bonn, considered that all the onyxes of the present day are the result of the above treatment, and there is good reason to believe the same to be true of many of the ancient ones. In confirmation of this view, see a chapter on gems in 'Chambers's Edin. Journal,' Nov. 1855, for authenticated instances of stones of fictitious character having been sold for costly gems.

The Egyptians more than 3000 years ago succeeded in counterfeiting precious stones. Pliny says, "They succeeded so completely in the imitation as to render it difficult to distinguish false from real stones," and considers the art to have been a far more lucrative piece of deceit than any other devised by the ingenuity of man (Pliny, chap. 37). And again, in writing of fraudulent practices (chap. 93), he says, "yet how many sorts of gems there be still so painted."

One other fact in connection with other frauds may be worth recording. Upper Egypt is known to yield agates, though of a different kind from those of South America, and less abundant. Travellers from Europe passing through that country purchase the American for Egyptian specimens. From personal knowledge I can state the same with regard to Palestine and Greece.

Agates are usually found imbedded in igneous rocks, or as loose nodules set free by the decomposition of the matrix. The erupted matter appears to have originally assumed a vesicular texture by disengagement of gas or steam, the viscous nature of the molten rock preventing the collapse of the walls of these bubbles. Into the cavities thus formed, silicious solutions were ultimately introduced; and from these solutions the silica was slowly deposited, layer upon layer in regular sequence, as a lining on the interior of the cavities. By variations in the character of the solution, the deposits were sometimes in the nature of gelatinous chalcedony and sometimes in that of crystalline quartz; thus producing the differences in the concentric layers which enter into the constitution of an agate. Most of the South American agates, which are now so largely cut and polished in Germany, are found as pebbles in the beds of rivers; the old lava which formed the enclosing rock having suffered decomposition and set free the hard silicious nodules.

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* 'Quart. Jour. Geol. Soc.' (1848), vol. iv. p. 209.

The other principal centre for cutting and polishing stones is at Ekaterineburg (West Siberia), but here the stones are of a more costly character than those worked at Idar; are not artificially coloured, and are confined to the productions of the country, and include Sapphire, Topaz (Siberian Diamond), Beryl (Aquamarine), Emerald, Rock Crystals of various tints, Amethysts, Rhodonite, Malachite, Tourmaline, and Jaspers in endless varieties. Many of these, cut by the natives, and artistically grouped in imitation of the fruits of Siberia, are remarkable as works of art.

At the government factory of Ekaterineburg I saw (May 1883) a block of Rhodonite of 90 tons weight about to be operated on.

FOSSILS.

So many popular errors exist in relation to Geology that those who study it for the first time will have much to unlearn. For example, until a comparatively recent date, the presence of fossil organisms in elevated districts, such as the Isle of Portland, was ascribed exclusively to the effects of the Noachian Deluge; whereas it is now shown, beyond any reasonable doubt, that the various animals, so found, lived at the time when the particular strata were deposited in which their fossilised remains now occur. The present position of the beds is due rather to the rise of land than to the lowering of the waters.

Fossils often being the only means at hand for identifying strata, a knowledge of them is indispensable to those who would recognise a formation from its fossil contents. Such a knowledge is also necessary for determining whether a formation be of marine, freshwater, or terrestrial origin, as well as the conditions attending their deposition, such as depth of water, approximate temperature, and other data alike essential, in order to arrive at a correct interpretation of geological phenomena.* Thus, certain genera of recent mollusca only thrive in places where they are uncovered at the falling tide; others exist only in deep water; while some, not adaptable to either exclusively, require for their existence salt water with occasional inlets of fresh water or *vice versâ*.

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* But to this the Caspian offers a remarkable exception. This inland sea, of about 370 miles in length, is salt to saturation towards the southern extremity and where it abounds with marine animal life. While the Volga, the largest of European rivers, empties itself into the northern end, there establishing conditions favourable to the existence of freshwater animals. Singular modifications of structure have resulted from this mingling of salt and fresh water.

The origin and distribution of species, whether of ancient or recent forms, has engaged the attention and study of most eminent naturalists, whose varied opinions may be resolved into two propositions:

1. "Every specific form is conceived to have sprung into being at a certain point on the globe at a definite epoch of time" (Prof. John Phillips), thus giving a birthplace in time and space for each species, or it may be genus, and assigning to each, within certain limitations, a permanent character, the extent or range of such variation being the point where naturalists would differ.

2. "That all forms of life in the past, present, and those that may follow, originated from one or more rudimentary types, having the quality or power of self-development." This theory of progressive development or "evolution," according to the views of some of its advocates, admits of no limitation.*

In support of this latter view, it is contended that, from the first appearance of organic life on the globe, there has been a continual advance from a lower to a higher type (though subject to the possible discovery of vertebrated animals in older formations). Our increased knowledge of fossil animals and plants, which, as regards Great Britain, have been tabulated by Prof. John Morris and Mr. Etheridge, shows that all the species, and a great part of the genera, of the more ancient rocks have become extinct. Of the numerous forms of Cephalopods of the Palæozoic and later formations, the only existing member is the Nautilus of the Indian

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* On the doctrine of a limited evolution Sir C. Lyell thus expresses himself: "When I first came to the notion of a succession of extinction of species, and creation of new ones, going on perpetually now, and through an indefinite period of the past, and to continue for ages to come, all in accommodation to the changes which must continue in the inanimate and habitable earth, the idea struck me as the grandest which I had ever conceived, so far as regards the attributes of the Presiding Mind. For . . . what powers and qualities a new species must have in order to enable it to endure for a given time! . . . It might be necessary, perhaps, to be able to know the number by which each species would be represented in a given region 10,000 years hence, as much as for Babbage to find what would be the place of every wheel in his new calculating machine at each movement. . . ."—'Life of Sir Charles Lyell,' vol. i. pp. 467–8.

Ocean, which, like its predecessors, seems destined ultimately to disappear. One of the few surviving types is that of "Lingula," which, being found in the Silurian and Cambrian rocks, still has its living representative in the Indian and Pacific Seas, while the Terebratulidæ,* with nearly an equally long line of ancestry, and furnishing a greater number of species and individuals than any other Family of Mollusca, is now represented by not more than 100 species. No "Graptolites" have been found in rocks later than those of the Silurian age; nor "Trilobites" later than the Carboniferous; nor "Ammonites" in rocks of more recent age than those of the Cretaceous period.

In the year 1822 the recorded number of species of organic remains found in Great Britain amounted only to 752. Up to the year 1874, the number, as computed by Mr. Etheridge, was 13,276.† When it is considered how the number of known fossils is ever augmenting, and moreover almost the whole of these are of animals that live in water, and further that it is only under favourable conditions animal remains are preserved, it will be seen how incomplete is the record of past life. For example, all that is known of certain gigantic animals of the Triassic and some other of the older rocks are the *impressions* of their footsteps, the most remarkable of which are the tracks of *Brontozoum* observed on the sandstones of the Valley of the Connecticut, the length of whose stride measures six feet nine inches. These footprints are said to be in "untold thousands," scattered over vast areas, yet not a bone or aught of their remains have been discovered, excepting a fragmentary skeleton of one of the smaller forms.‡ Though each formation is characterised by its peculiar fossils, some species pass upwards into the succeeding beds, and of these the lower organisms are the last to disappear, and consequently have the greatest geographical as well as vertical range; but the greater the break or disparity of any two formations, the longer would be the intervening period.

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* The Class "Brachiopoda" differs from other mollusca in having an internal calcareous framework or skeleton, and a prominent beak, through which a muscular ligament passes, by which the shell is attached to some other object. Nearly two thousand fossil species have been described, and the list is increasing. Living examples generally inhabit deep water and rocky situations. Two species, viz. *Argiope cistellula* and *A. capsula*, are found in the West Bay, off Portland.

† 'Past and Future of Geology,' by Prof. Prestwich, p. 21.

‡ 'Huxley's American Addresses,' p. 44.

Important considerations are involved in the existence of the same species in many places, and in districts far remote from each other, taking for examples formations such as the Oxford Clay of England, Moscow, and South Africa; and if the doctrine of "specific centres of creation" be held, the time demanded for their migration to these widely-separated areas must have been immense. As the contemporaneity of such distant deposits cannot be strictly defined, Prof. Huxley proposed the term "homotaxis," that would include the notion of time or contemporaneity, and express only similarity of order and serial relation so far as being within the same great epoch, and not of "synchronous origin."*

Example.—Supposing that at some future geological period, when the ocean bed of European Seas is raised to dry land, the Crag of Suffolk were compared with the remains found in the present European or Northern Seas, because many species were in common, it would be said they were contemporaneous.

FORMS OF PETRIFACTION.

Fossils formerly included not only the fossilised remains of organised bodies, but also minerals, ancient pottery, and all other relics dug out of the earth, but the term is now only applied to remains of animals and plants. These, though generally penetrated by earthy or mineral matter, are not necessarily so. In some instances the original shell or bone has undergone but little change of structure, while in others there has been an entire substitution of parts. The following will be found to include the various conditions under which fossils are preserved.

1. Where the constituent parts remain the same, without having undergone any other change than that resulting from decay; as, for example, shells of comparatively recent date, cavern-bones, elephant, and other diluvial remains.

2. Where the substance has become *carbonised*, as is the case with common coal, jet, and lignite.

3. Where the original shell or bone has been replaced by some earthy or mineral substance, determined by the chemical nature of the stratum in which the body is imbedded. In the harder rocks, carbonate of lime,† sometimes silica or flint, is substituted for the

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* 'Quart. Journal of Science,' 1865, p. 622.

† Most Shells are mainly composed of *carbonate* of lime; Bones of *phosphate* of lime.

original shell. In clayey beds, where iron pyrites is diffused, the original substance is frequently replaced by sulphide of iron. Fossils in this condition have a brassy appearance and a metallic lustre.

The 'Bulletin of the Geological Society of France' (1879) gives a description of an Ammonite of silver, found in a silver-mine at Caracoles, in South America, with other Ammonites of the species *plicatilis*, and *perarmatus* (Oxfordien.) not thus mineralised. The specimen in question had its original substance entirely replaced by Chloride of Silver.

Notwithstanding these changes of particles, the original structure of the shell or plant, however delicate it may have been, is frequently preserved.

4. *Casts.*—Where the shell itself has disappeared and left only a hollow, as in the screw-stone and other fossils of the Portland roach-bed. In these the shell has entirely disappeared, each particle, as it was gradually dissolved and carried away, having been replaced by one of calcareous spar, derived from the limestone in which it was imbedded, until ultimately a facsimile was produced of the original shell. This in its turn was subsequently carried away in solution by the percolation of infiltrating water, leaving only a hollow cast or mould of the shell. Though the dissolving away of the shell has left a vacancy, the outer surface bears the impress of the external form of the shell, by means of which the species may be ascertained.

Dr. Sorby considers that the difference in the state of the preservation of fossils is according as they were originally composed of Calcite or Aragonite.*

Calcite shells of which the genera *Gryphæa*, *Ostrea*, *Perna*, *Mytilus*, and *Brachiopods* are the most abundant, by resisting disintegration, retain their original structure; while in the case of those in which there is a large portion of Aragonite the shell is removed and represented by casts, as in the *Trigonia*, *Cerithium*, and other Aragonite shells of the Oolite.

Another large and important class of fossil remains are those of Plants, of which in some cases the bare impressions only are preserved, though sufficient to determine their generic, and sometimes even their specific forms.

A form of fossilisation occurs in the shaly beds of the Oxford and

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* Aragonite differs from Calcite in its greater hardness, and in containing 1 to 4 per cent. of carbonate of strontia. It has also a different cleavage.

Kimeridge series, where the harder parts of the shell have disappeared, and the internal and nacreous portion only is preserved. Foot-tracks of extinct animals, and impressions of rain-drops of an ancient world, are also included in the term fossil remains; as also Meteorites found in stratified deposits, and which must consequently have fallen during a former geological period. To these may also be added *Fulgurites*, a term applied to certain appearances in ancient strata, caused, it is supposed, by lightning, and hence called *fossil lightning*; as, in the same manner, particular cracks considered due to the sun's rays, have been metaphorically termed sun-cracks and *fossil sunshine*. Fulgurites also include a singular product of lightning, vitrifying silicious sands, as in Silesia, where it produces a tubular aggregation of particles, penetrating the surface to the depth of one or more feet; such tubes or pipes not being fusible by artificial heat.

DESCRIPTION OF FOSSILS FOUND IN THE WEYMOUTH STRATA.

Ammonites (*Cornu Ammonis* of old authors).

A wide-spread and familiar fossil, named after Jupiter Ammon, from its supposed resemblance to the horns with which the head of that Deity was represented to be crowned. Early writers refer to them as fossilised rams' horns, others as coiled snakes* in a state of petrifaction.

The legend runs that the good people of Whitby having besought St. Hilda, that the snakes might either be destroyed or rendered harmless, she prayed their heads off, and their conversion into stone. This belief may have given rise to the popular notion that an ammonite in a perfect state must have a head; and the inquiry for such has led the Portland quarrymen to carve the termination of the last whorl into the resemblance of a snake's head.† Such *perfect* specimens may be had for a few shillings. To correct this error it is only necessary to state that the ammonite is not the animal but the shell which it inhabited, the former (a soft mollusc) being incapable of preservation. These interesting fossils are found in rocks of the secondary period in all parts of the globe, first appearing in the Trias and terminating with the Chalk. Though of marine origin ammonites have been met with on the Himalayan range of mountains, at a height of 17,000 feet above the level of the sea. Above 300 species are recorded from the British strata alone, varying in size from less than an inch to more than three feet in diameter. The *Ammonites giganteus* found in the Isle of Portland attains this latter size. The example now before me measures 38 inches across.

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* This idea is embodied in the following lines from 'Marmion':—

"Of thousand snakes, each one
Was changed into a coil of stone,
When holy Hilda prayed."

† Better known to the quarrymen as coiled and petrified Conger Eels.

A fossil, *Aptychus latus*, supposed to have been a bivalve shell, was named on that supposition *Trigonellites*, until the late Dr. S. Woodward discovered its true relation. It is now regarded as the operculum of the Ammonite, which, closing the outer chamber, served to protect the soft body contained within the shell.

Some naturalists considered the ammonite to have been an internal shell, i. e. enveloped by the animal. This opinion was partly founded on the size of the outer or last chamber, which bore too small a proportion to the entire shell to have contained the animal; but in the best preserved specimens the last chamber forms two-thirds of the outer whorl, and therefore is proportionably as large as the outer chamber of the nautilus. The air-chambers enlarge with the growth of the shell, but have no communication with each other, the cell being hermetically closed as each partition was successively deposited. The septa or divisions, besides adding strength to the shell, appear to have been necessary, as in the case of the nautilus, to counterbalance the increasing weight of the animal as it grew, each chamber being lighter than the quantity of water it displaced. As is the case with the nautilus, the weight of the animal and shell combined was so perfect a counterpoise to the medium in which it floated, that the slightest effort of the animal would cause it to rise or sink. In the nautilus, this is effected by the ejection of a fluid into the siphuncle or pipe which passes through the chambers, and the adjustment is so perfect that a few drops suffice to sink animal and shell, and *vice versâ.*

The shell of the ammonite is distinguished from that of the nautilus by the siphuncle being situated on the outside of the shell. In the latter it passes through air-cells in its centre. The shell of the ammonite also offers mechanical contrivances of the most perfect description. Its numerous partitions, fluted exterior, sutures, ribs, keel, spines, and bosses, all contributed to afford the greatest strength combined with the least possible weight. Some specimens, especially those from Lyme Regis, having their cells filled with a crystallisation of carbonate of lime (Calcite) are susceptible of a high degree of polish. The last chamber generally contains a different substance, supposed to arise either from the decomposition of the animal, or, from its being thus occupied, that the surrounding matter was prevented from entering. About forty species occur in the Weymouth strata, varying in size from the minute species which is found in the Oxford Clay, to the *A. giganteus* of the Portland series.

NOTE.—The small-chambered marine shell *Serpula* is, of existing genera, the nearest allied to the ancient Ammonite. A true recent Ammonite is among the possible discoveries of Oceanic life.

Belemnite (signifying *a dart*).

A singular fossil not found in a recent state; straight, cylindrical, and pointed like a pencil at one end, with a conical cavity at the other; hard, of a crystalline texture, dark-brown colour, and emitting, when rasped, a peculiar horny odour. Unlike the ammonite, its shell was enveloped by the animal; resembling in this and some other characters, the *sepia* or *cuttle-fish*. It was also a compound shell composed of the following parts:—

1. The *guard* or *sheath*, *a*; see Figs. 11, 12, 13, the portion generally preserved.
2. *Phragmacone* or *alveolus*, *b*; a conical shell lodged in the cavity at the base of the sheath, and consisting of a series of concave air-cells pierced laterally with a siphuncle, answering to the air-chambers of the ammonite and nautilus.
3. Above the phragmacone commenced a calcareous or horny plate, *c*, enclosing an ink-bag and other appendages. From recently discovered specimens, with these various parts preserved, Prof. Owen has described the probable character of the animal to be that of a dibranchiate, eight-armed cuttle fish. It is supposed that the belemnite generally maintained a vertical position, and that its dart-like bone or shell gave it considerable swiftness of motion.

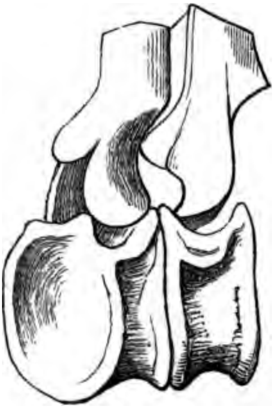
Belemnites are found in great abundance. Commencing with the Muschelkalk of Germany and Lias of Great Britain, they enter into all the ascending strata, disappearing with the Upper Chalk, and like the Ammonite never appearing again. Few fossils have given rise to so many speculations. M. de Blainville enumerates ninety-one authors who have written on them, commencing with Theophrastus (died B.C. 287).

The following are among the names by which the Belemnites were designated:—*Thunder-bolts*, *arrow-heads*, *petrified fingers*, *St. Peter's fingers*, *stalactites*, *teeth*, *spines of echinidæ*, *petrified amber*, &c.; and in old works on Materia Medica, they are recommended to be used in a pulverised state as a remedy for nightmare, dressing wounds, &c. They are abundant in the lower beds of the Kimeridge Clay at Sandsfoot Castle Cliff.

SAURIANS.

Of the gigantic reptiles that existed during the secondary period, the following (belonging to the order *Enaliosauria*, or marine saurians) are represented in the Weymouth strata.

FIG. 58.



Vertebræ of Ichthyosaurus. Oxford Clay. Weymouth.

*Ichthyosaurus** (from the Greek, signifying a fish-lizard) was an animal combining the characters of lizard and fish, and in size the nearest approach to the whale, some species attaining a length of from 40 to 50 feet. The vertebræ, numbering 140, are concave as in fishes, and not solid as in the crocodile. The space between each pair was filled with a fluid which insured the utmost play and elasticity of the parts in question. These become smaller towards the tail, somewhat flattened, and terminating in a caudal fin, flat in a vertical direction, and in a fossil state always found bent downwards. The jaw was furnished with 180 teeth, not set separately, but in a groove or furrow. These they had in succession. The second or new tooth, and sometimes the third, may be detected, where the first has not been shed. The eye is remarkable both for its peculiar construction and large size in proportion to that of the animal, and from its posterior position. Both the teeth and the vertebræ offer distinctive characters for the determination of species. Four paddles, somewhat similar to those of the whale, supplied the means of locomotion. Aquatic in their habits, they lived in estuaries and shallow bays, feeding on fish, the undigested remains of which are found within their skeletons in a fossil state. There are upwards of thirty described or known species. The Lias of Charmouth and Lyme Regis is a well-known depository, whence specimens have been obtained that have found a place in every geological collection in Europe.

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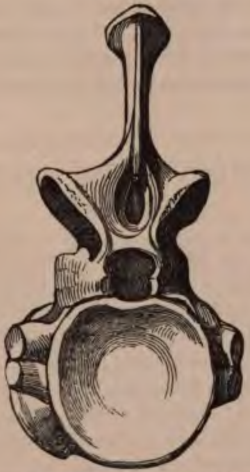
* The description of this and the following genera of saurians is derived from Prof. Owen's published works.

Plesiosaurus (from the Greek, signifying near to a lizard).

The Plesiosaurus was an animal of nearly equal dimensions to the Ichthyosaurus, but differed from it in organisation, especially in the greater length of its neck, which was longer in proportion to its size than is the case either with the swan or giraffe. Hugh Miller aptly compared the Plesiosaurus to a snake pushed through the body of a turtle. The vertebræ are ninety in number, thirty-three of which belong to the neck. Compared with the Ichthyosaurus the head is shorter, the vertebræ are smaller in diameter, but considerably thicker. The paddles are also larger. Its general structure indicates great agility and speed. It was a shore-frequenting animal like the turtle: more so than the Ichthyosaurus. Cuvier conjectured, from certain anatomical appearances, that it had the power of changing the colour of its skin, and further adds, with regard to its general form, that it possessed characters altogether the most monstrous that have yet been found amid the ruins of a former world. There are twenty known species. *Plesiosaurus planispondylus* occurs in the Oxford Clay of Greenhill and Radipole Backwater, and *Plesiosaurus megapleuron* (Owen) in the lower beds of the Portland Stone in the Isle of Portland.

FIG. 59.



Vertebræ of *Plesiosaurus arcuatus*, from the Oxford Clay of Weymouth.

Pliosaurus.—A genus having somewhat of the character of both Ichthyosaurus and Plesiosaurus, but bearing a greater resemblance to the crocodile than either of the above. The teeth are of greater thickness compared with their length; the outer sides are much flattened, besides being longitudinally grooved, and having an unusually lengthened fang; they are fewer in number, and set separately in a socket as in the crocodile. The vertebræ bear more resemblance to those of the Ichthyosaurus, but are less concave. Only two species are recorded—both from the Kimeridge Clay. No entire animal has yet been found. The teeth, a portion of the head, vertebræ, and other bones of the *Pliosaurus brachydeirus* (Owen), deposited in the Dorset County Museum, are from the Kimeridge Clay of Ringstead. Single vertebræ are not uncommon at Osmington Mills, Ringstead, Kimeridge, and Portland.

Teleosaurus.—An animal more adapted for motion on dry land than most other saurians, and therefore like the modern crocodile, most probably amphibious in its habits. The first recorded specimen, from the Lias-shale of Whitby, measured 18 feet in length.

The skin of the *Teleosaurus* was overlaid with massive plates or scales, forming a kind of coat of mail like that of the crocodile. The teeth were about 140 in number, and slender, of which the first, on either side of the jaw, was long, and the others alternately longer and shorter. The jaws of the Teleosauri were long and attenuated.

Locality—Lower Calcareous Grit of the Coral Rag of Nothe Point, Weymouth.

LIST OF DESCRIBED SPECIES INCLUDED IN THIS VOLUME.*

Lima Coodei, n. sp. fig. 36.—Shell very oblique, compressed, umbones contiguous, depressed, and but little produced; anterior border straight, not excavated, slightly gaping: posterior border and auricle elliptically rounded; ribs (about 28) large towards the middle of the valves, diminishing regularly in size towards both extremities of the shell, depressed, smooth, and much wider than the interstitial spaces; lines of growth faintly marked and irregularly disposed. Height, 2¼ inches; anterior posterior, 2 inches; diameter through both valves, 1 inch.

Locality—Portland Stone, I. of Portland.

Corbicella Portlandica (Psammobia ?), n. sp. fig. 37.—Shell transversely ovate or subquadrate, compressed inequilateral, umbones small, placed about one third from the anterior margin, which is rounded; posterior side with a rather obtuse ridge extending from the umbones to the margin, which is somewhat attenuate; surface marked by lines of growth. Allied to *Corbicella bathonica* (Lycett).

Locality—Portland Stone, I. of Portland.

Sowerbia Dukei, n. sp. plate 7, fig. 6.—Shell ovate, oblong, equilateral, thick anteriorly, and posteriorly rounded. The cast figured shows the cardinal area, the prominent anterior and posterior muscular impressions, the pallial line and slightly inflected sinus.

This shell belongs to a small group of oolite forms, for which D'Orbigny proposed the name *Sowerbia*, to which also belongs the genus *Isodonta* of Buvignier.

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* First described, by Prof. J. Morris and Dr. Lycett, in Ed. 1 of this work, 1860, pp. 172–4.

Locality—Portland Stone (roach bed), Isle of Portland, associated with *Cerithium Portlandicum*, *Trigonia incurva*, &c.

Cerithium Damonis, n. sp. Lyc. fig. 18.—Shell elongated; volutions eight to nine, slightly convex, narrow, their height being only half the dimensions of their lateral diameter, deeply constricted at their junctions: tubercles in two rows, equal, regular, very prominent, distinct, from thirteen to fifteen in volution. Aperture apparently small, canal short and not recurved. Length ten lines, diameter three lines.

Locality—Oxford Clay, north of Weymouth.

RETROSPECT.

In the foregoing part of this manual it will have been seen that the district under review has been subjected to a succession of changes; that the rocks which are now dry land were formed at the bottom of the sea, and that both land and water have many times interchanged places. Though we cannot here take cognizance of any other formation lower than the Jurassic, yet the older strata, which are of considerably greater thickness, lie beneath, and may at some future epoch be brought to the surface. That the strip of land on which Melcombe is built was at no distant period covered by the sea—from which it is still gradually emerging—is evident from the composition of its mass, viz. shingle, gravel and sand; but immediately underlying these comparatively recent accumulations is the Oxford Clay, a stratum formed from the detritus of older rocks at the bottom of another and more ancient ocean, the boundaries of which had nothing in common with the present coast. *Ammonites* and various other mollusca, so numerous in this formation, belong chiefly to genera which have their allied representatives in warm seas of the present day. The remains of *Ichthyosauri* and *Plesiosauri*—shore-haunting creatures—would imply that at one period a shallow sea-bottom or shore was not very remote.

Though few animal forms which lived during the deposition of the Oxford Clay survived to the succeeding age, yet other forms appear; for the sea, during the deposition of the Coral Rag, swarmed with life—*Sharks*, *Cephalopods* and other *Mollusca*, together with *Crustacea*, *Echinidæ*, *Corals*, all of which, having lived their appointed time, were replaced by other forms, who in their turn yielded to some general law by which all species eventually die out, never to reappear. The succeeding strata are a repetition of marine deposits, each change involving the successive creation or evolution, and extinction of animal and vegetable life. Thus, in the Kimeridge Clay, a formation rich in organic remains, there occur huge Saurians of the genus *Pliosaurus*, which are only found in the Kimeridge Clay; consequently the whole lifetime, not merely of the individual, but of the entire race of these animals, was consumed during the accumulation of this one stratum. During all this time, the strata out of which were subsequently formed the adjacent hills as they now exist, were submerged beneath the sea, until the close of the Portland Oolite, which appears to have been the first land raised from beneath the Jurassic sea. From certain changes in the configuration of the land the area so raised became a freshwater lake, covering a surface, the minimum extent of which is marked by the "cap." That this change was rapid in its character is proved by the sudden disappearance of marine fossils and the substitution of freshwater shells between the Portland and Purbeck formations, the line of separation * being a thin bed of stone, the lower portion of which is Portland (marine), and the upper Purbeck (freshwater). Subsequently, by a further elevation, this estuary or freshwater lake became emptied of its contents, or was raised sufficiently to become dry land. This period, so distinctly marked, forms one of the most singular and remarkable features of the district. A forest of tropical luxuriance sprang from the land recently raised from the sea.† Coniferous Trees and Cycadeæ, although changed into stone, still lie in their primitive soils. Though geologists do not venture to give an opinion upon the length of time necessary for the accumulation of any one stratum composing the Earth's crust, yet the condition of the fossil trees of the Portland dirt-bed demonstrates that the whole period which gave origin to the growth and destruction of this ancient forest was passed during the formation of a deposit but a few inches in thickness.

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* In the Island of Portland there is a thin seam of clay above the Portland beds.

† "There rolls the deep, where grew the tree.
O earth, what changes thou hast seen!
There where the long street roars, hath been
The stillness of the central sea.

"The hills are shadows, and they flow
From form to form, and nothing stands;
They melt like mist, the solid lands,
Like clouds they shape themselves and go."

The relative position of the land and water is once more changed, for the forest is submerged, and becomes the bed of a freshwater lake by a transition so gentle that the light soil of the dirt-bed is not removed. Of the succeeding beds, which consist of alternate land, shallow freshwater, and brackish-water deposits, the Rev. Osmond Fisher has defined 162, each having a distinctive character most prolific in new forms of life, and terminating with the Wealden formation, which closes the Jurassic age. The area, which is our standing point, becomes once more the bed of another sea, the waters of which teem with new life. This period, known as the Cretaceous, embraces strata, commencing with the Lower Greensand and terminating with the Chalk, and is of vast thickness. Then the hills that now meet the eye had no existence.

The Tertiary formations are here but scantily represented, but their number and thickness elsewhere show that the period over which they extended was incalculably great. At the close of the Tertiary period, the bed of the sea had been raised so as to form dry land; but the sea-barrier, which now separates us from continental Europe, had then no existence.*

Later still was that denudation by which large portions of the superior strata were removed, the valleys excavated, and the surface of the land had much of its present form and outline given to it.

This period, though but a continuation of geological history, is one of more than scientific interest, as within this epoch we meet with the first traces of man, not his fossilised remains, but the relics of his handiwork.†

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* That Great Britain, geologically speaking, belongs to the Continent, is placed beyond all reasonable doubt. The Oolite of Weymouth has its counterpart on the coast of Normandy. The Chalk of Dorsetshire and of the Isle of Wight resembles that on the coast of the Seine Inférieure, and there is a similar correspondence of parts in the Tertiary formations. Besides this similarity in the structure of the land on both sides of the Channel, there are evidences derived from the living species of animals and plants of Great Britain and the Continent of former direct land connection. Prof. E. Forbes has shown that the animals and plants of living British species are chiefly of Germanic types, and could only have found their way hither by direct communication with the Continent over land.

The greatest sea-depth between Weymouth and Cape la Hogue is 45 fathoms, between Dover and Calais 30 fathoms.

† The following division of prehistoric time — known also as the Quaternary period—has been proposed; though the line of separation is

Again, other tools, and objects of human craft are found in caves and river débris, mingled with the remains of quadrupeds which have long been extinct. Weapons of war and the chase, and artistic drawings on polished bones,* occur in the upper deposits, while in the lower are implements of ruder production. Among the extinct Mammalia there are three species of *Rhinoceros*, two species of *Elephant*, three species of *Bear*, *Hippopotamus*, *Bison*, *Wild Boar*, *Hyæna*, *Irish Elk*, *Reindeer*, and *Cave Lion*. This latter (the "British Lion," as he has been styled) was huge in size and unrivalled among the lower animals. But the central figure of this formidable fauna, writes Prof. Dawkins, "is proved to have been man: a river-drift hunter, who held his own in the terrible struggle for existence." Further, referring to this prehistoric man, Prof. Dawkins remarks: "He comes before us endowed with all human attributes, and without any sign of a closer alliance with the lower animals, than is presented by the savages of to-day."

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not by any means well defined, inasmuch as the ages of iron, bronze, and of polished stone have been, and are still, going on side by side in many parts of the world:—

1. That of the drift, also called the "Palæolithic period."
2. The later, or polished stone age, "Neolithic period."
3. The bronze age.
4. The iron age.

'Prehistoric Times,' by Sir John Lubbock, F.R.S.

Amongst the most significant of recent discoveries in our own country is that of the worked flints of Brandon, inasmuch as the manufacture of these implements has been apparently carried on there without interruption from Neolithic times, down to the present day. Gun-flints are still manufactured at Brandon for the African market, where Mr. Skertchly thinks "it can be confidently asserted that we have, as it were, an outline of the Stone Age—that the flint-knappers are the direct descendants of the old workers in stone." 'Ancient Stone Implements of Great Britain,' by John Evans, F.R.S. 'Memoirs of the Geological Survey'—'On the Manufacture of Gun-flints and on the Connection between Neolithic Art and the Gun-flint Trade,' by Sydney B. J. Skertchly, F.G.S., p. 73 (1879).

* The sketches and carvings of animals done by the old cave-men of Europe have so artistic a touch, that some have supposed them to be modern forgeries. See 'Anthropology,' by E. B. Tylor, p. 301.

Some of the arrow-heads found in the Neolithic workings at Brandon are described as triumphs of skill not reached by modern workers. (See S. B. J. Skertchly, in 'Memoirs of Geological Survey.')

Prof. Virchow,* at the Jubilee Conference of the German Association of Naturalists, said, "We cannot teach, we cannot pronounce it to be a conquest of science, that man descends from the ape, or from any other animal. . . . . Nay, further, if we gather together the whole sum of the fossil men hitherto known, and put them parallel with those of the present time, we can decidedly pronounce that there are among living men a much greater number of individuals who show a relatively inferior type, than there are among the fossil known up to this time."

The late Professor Rolleston, of Oxford, with whom prehistoric Anthropology was a special study, has in his published writings many times given expression to a similar opinion.

There are other indications of man's presence at that early period when he shared the possession of this part of Europe with the wild animals referred to. Worked flints, with mammoth-bones, have, as already described, been found in this and other parts of Dorsetshire, while in the neighbouring counties, and more especially in the Mendip Hills, and Kent's Cavern, at Brixham, the *Hyæna*, *Cave Bear*, *Rhinoceros*, *Cave Lion*, and other extinct carnivora representing hundreds of individuals, have been discovered, with human relics. It is, therefore, highly probable that these animals roamed over Great Britain, when it was united to the Continent, retiring it may be to their caves to die, or their carcases may have been dragged in for prey, as in the well-known cavern at Kirkdale, where the bones of some 300 Hyænas of all ages were found with masses of gnawed bones.† That man lived side by side with these extinct creatures, is beyond a doubt. When he first appeared on the Earth is a problem of the deepest interest, and apart from Revelation is the question which Science still asks. That many centuries may pass without producing any very perceptible change in the surface of the Earth, we know from the condition of the neighbouring tumuli, and other works of great antiquity.‡

From such evidences, what conclusions might be deduced, were it not that the object of this volume is to present facts, rather than to theorise?

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* A discourse at the 50th Conference of German Naturalists, delivered at Munich, 22nd September, 1877, "On the Freedom of Science in the Modern State," by Professor Virchow, Professor in the University, and member of the Academy of Sciences of Berlin.

† 'Reliquiæ Diluvianæ' (Dr. Buckland).

‡ The great Pyramid, though regarded as the oldest of existing structures, is built of a stone of comparatively recent geological age, viz. the Nummulite limestone, which is so called from the mass of Nummulites

As to the literal order of creation so often insisted on, either it belongs not to things revealed, or being revealed, it has not been interpreted; in other words the time has not yet come "for science to draw its final conclusions."

This retrospective survey of the revolutions and changes of which this area has been the scene, may be appropriately closed in the following words of a late distinguished philosopher:—The earth on which we live must ever be considered a proper subject of investigation. For man it was made, and so carefully prepared. "Its surface is the arena of our contentions, our pleasures, and our sorrows. It is to obtain a portion of its alluvial crust that man wastes the flower of his days, and prostrates the energies of his mind, and risks the happiness of his soul; and it is over, or beneath, its verdant turf that his ashes are to be scattered, or his bones to be laid. . . . To him it especially belongs to investigate the wonders it displays, and to learn the lesson which it reads."*

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which enter into its composition. At its base these fossils, derived from the disintegration of the rock above, have accumulated to a depth of several feet. Strabo also notices their occurrence, and described them as the petrified residue of the lentils consumed by the workmen during the construction of the Pyramid.

* Sir D. Brewster, Address, Brit. Association, 1850.

SWANAGE.

The geology of Swanage and the Isle of Purbeck,* though already referred to, requires a more specific and local description for those who may visit the various localities from Swanage, rather than from Weymouth.

The following is a summary of the formations visible on the coast from Studland Bay to St. Alban's Head :—

Middle Eocene	Lower Bagshot Sands and Clay.	
Lower Eocene	London Clay or Bognor Beds. Plastic Clay or Woolwich and Reading Series.	
Cretaceous	Chalk. Upper Greensand. Punfield Marine Beds. Hastings Sands and Weald Clay.	
Upper Oolite	Upper Purbeck Middle ,, Lower ,,	Purbeck Beds.
	Portland Stone Portland Sand	Portland Beds.

PORTLAND STONE. (Marine Oolite.)

The rocks forming St. Alban's Head are a repetition of the Portland beds of the Isle of Portland, distant 16 miles. Besides the visible strata, others are traceable for some distance below the sea, where with the confluence of the tides they help to increase the force of the "race." The coast on the east is somewhat striking, being of a bold and rugged character.

The hard strata built up in visible layers, present a perpendicular face, while at the base are caverns, the retreat of innumerable sea-fowl. Some good beds of the Portland Oolite have here long been worked under ground, in galleries, as at "Win Spit" and "Tilly

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* So called from being bounded on the north by the river Frome and Poole Harbour, on the west by Luckford Lake, and south and east by the sea.

Whim," and are shipped from the ledges in vessels brought alongside the cliffs when the weather permits. From the deck of the steamer which makes the passage between Swanage and Weymouth the stratification is clearly seen. The Portland Oolite extends to Durlston Bay. Large *Ammonites*, *Ostrea*, *Trigonia*, and other characteristic fossils are met with throughout.

PURBECKS (Freshwater), DURLSTON BAY.

Owing to the inclination of the strata, the Purbeck Beds, viz. *higher*, *middle*, and *lower*, are successively displayed in the cliffs between Durlston Head and Peveril Point. The continuity of the beds is broken by several *faults*, one immediately north of Durlston Head, and another near the middle of the bay. At Peveril Point the beds are still more disturbed. The direction and range of these various faults are laid down in the map (sheet 16), and in the Horizontal Sections (sheet 56), of the Geological Survey. The following vertical section by Mr. Bristow, being from the fulness of its information a summary of the Geology of the district, is here given in full. The section, as published by the Geological Survey (sheet No. 22, of the Vertical Sections), is distinguished for its minuteness of detail, and beauty of execution.

SECTION OF THE PURBECK STRATA OF DURLSTON BAY, DORSET.

Measured in the Cliffs by H. W. Bristow, F.R.S., F.G.S.

The Fossils named by Prof. E. Forbes, F.R.S.

No. of Bed.	Character of Rock and Organic Remains.	Thickness.	
		ft.	in.
	UPPER PURBECK.		
	Upper Cypris Clays and Shales.		
93	Sands, Clays and Shales .. .. Scales and Teeth of Fish. Paludina carinifera, Cypris tuberculata.	4	0
92	Clay full of Paludina carinifera	1	0
91	Compact blue Shell-Limestone (Purbeck Marble) containing green specks. Paludina carinifera.	4	0
90	Shale and Clays, with a bed of pale clay crowded with Paludina carinifera at 4 feet. Cyclas, Cypris. At 3 feet occurs a band of crystalline Limestone 1¼ inch thick, with well-weathered Cypris on the upper surface.	11	0
89	Compact red Shell-Limestone (Purbeck Marble), with much green matter. The surface of the bed is covered with scales and teeth of Fish, Unio, Paludina carinifera, &c.	4	6
88	*d* Dark-grey Shales, with bands of ferruginous and shaly sands and thin seams of beef (or fibrous carbonate of lime) towards the lower part. 2 feet. Cypris, Cyclas, Paludina carinifera. *c* Thinly-laminated green Sands. *b* Thin bands of Limestone with Cypris and Cyclas. *a* White sandy bands. At 9 inches from the bottom, very thin laminæ of Beef occur in yellowish shales.	5	4
87	Unio Bed. Green sandy Limestone with greenish laminæ and containing Cyclas, Paludina, and white calcareous concretions.	1	0
86	Dark-grey Cypris-shales, with white sandy bands at the upper part.	2	0
85	Green sandy Limestone (Marble Bed) with greenish laminæ and white calcareous concretions. Unio, Paludina.	1	6
84	*Dark-grey Shales* (full of Cypris) with bands of sandy Limestone. At 8 feet a band of hard, blue, crystalline Limestone.	11	6

SECTION OF PURBECK STRATA OF DURLSTON BAY—*continued.*

No. of Bed.	Character of Rock and Organic Remains.			Thickness.	
				ft.	in.
	UNIO BEDS.				
83	*Irregular Limestone,* with Cyclas; Paludina carinifera, and comminuted shells. (Breaks with a blue fracture.)			0	9
82	*Sandy Clay and Cypris-shales*			2	0
81	CROCODILE BED. *Band of irregular Limestone* full of vegetable matter; Unio; Paludina; Fish; Turtle; Crocodile; Coprolites.			0	6
80	*Sandy Shale:* Large Paludina			1	0
79	*Limestone,* the top of the bed covered with Unio.			0	6
	UPPER BROKEN-SHELL LIMESTONE.				
78	SOFT BURR. Comminuted Shell-Limestone. *Thick beds of compact sandy Limestone,* chiefly made up of comminuted shells (principally Cyrena) with sandy seams and concretions: Unio; Paludina (very numerous), Fish and Turtle. Used in the old Tower of Swanage Church, in the restoration of Wimborne Minster, and for building the School House at Kingston (Dorset). Note.—The Upper Purbecks are marked by the presence of Cypris gibbosa, C. tuberculata and C. leguminella.			10	0
	MIDDLE PURBECK.				
	CHIEF "BEEF" BEDS.				
77	*Sandy and dark Alum-shales* with thin bands of Fibrous Carbonate of Lime, locally called "Beef" and "Horseflesh," by the quarrymen.			1	8
76	Limestone and Shale..			0	10
		ft.	in.		
	b Hard and grey sandy Limestone with Cypris	0	7		
	a White sandy Shale with Cyclas	0	3		
75	White sandy Shale with much blue Limestone. Cypris.			1	6
74	Dark Alum-shales (as follows)			10	0
	d Dark Paper-shales with a white and yellow efflorescence on exposure; crystals of selenite and ochreous oxide of iron. Cyclas	4	0		
	c Harder and thinly-laminated dark Shales alternating with Beef and passing into	0	8		
	b Hard sandy Shales, passing into impure Limestone with thin seams of Beef ..	1	0		
	a Dark Alum-shales	4	0		

SECTION OF PURBECK STRATA OF DURLSTON BAY—*continued.*

No. of Bed.	Character of Rock and Organic Remains.			Thickness.	
		ft.	in.	ft.	in.
73	Hard Limestones and dark Paper-shales, as under:—			5	0
	e Hard band of dark-grey crystalline Limestone. Cypris .. .. 4 in. to	0	6		
	d Dark Paper-shales and Beef. Cyrena and Cyclas	1	4		
	c Band of hard, grey Limestone, with markings in relief on the under side of the bed	0	6		
	b Dark Paper-shales	1	0		
	a Hard Limestone with a 2-inch parting of shale. Cypris	1	10		
72	Dark Paper-shales, with a yellow efflorescence on exposure. Much Gypsum (fibrous) and small crystals of selenite. Cyclas. Bands of perished shells, with selenite and carbonaceous matter.			10	0
71	Beef and Selenite			1	0
	CORBULA BEDS.				
70	Bands of Limestone and a few Shale-bands A layer of large bivalves on the upper surface of the bed. Corbula, Fish, Iron Pyrites.			1	8
69	Beef and limestones in thin seams and bands			0	8
68	TOAD'S-EYE LIMESTONE			3	2
	d Pink Limestone, with a 1-inch seam of indurated marl. Melania, three species	0	9		
	c Pinkish Limestone, thin bands in shale	0	7		
	b Blue Limestone with Insect-remains	0	6		
	a Thin bands of blue Limestone in shale	1	4		
67	Very hard and greenish, rubbly and marly bed, crowded with Cardium, Pecten, &c.			1	0
66	Broken-shell Limestone, with Corbula, Cyrena, &c., overlying 6 inches of Alum-shale.			2	6
65	Marly Limestone			2	8
64	Alum-shales and beds of Limestone, as follows:—			13	5
	l Alum-shale	0	6		
	k Band of Shelly Limestone. Corbula, Cyrena, Fish-remains	0	8		
	i Dark Alum-shale	1	6		
	h Greenish Limestone and Alum-shale. Corbula, Cyrena	2	6		
	g Alum-shale	1	0		
	f Comminuted Shell-Limestone, with hard marly seams	0	9		
	e Dark Alum-shale, with Beef and small crystals of Selenite	1	6		
	d Hard, grey argillaceous Limestone and Indurated Marl	1	6		
	c Alum-shales with Beef coated with a yellow efflorescence after exposure	2	6		
	b Shell-Limestone	0	6		
	a Dark Alum-shale	0	6		

SECTION OF PURBECK STRATA OF DURLSTON BAY—*continued.*

No. of Bed.	Character of Rock and Organic Remains.	Thickness.	
		ft.	in.
63	Dark, irregularly-bedded, impure Limestone ..	1	6
62	Alum-shale with a little Beef .. .. The lower half of the bed is made up of bands of Limestone and Shale.	1	3
61	Marl, Limestone, and Alum-shale .. .. Pale Marl, 10 inches; Limestone, 2 inches; Alum-shale, 3 inches.	1	3
60	Dark Alum-shale and beds of Marl, with thin bands of Limestone and Beef.	3	9
59	Limestone with partings of shale. Cypris, Cyclas, Ostrea, Melania, &c., at the bottom part of the bed.	0	9
	SCALLOP BEDS.		
58	WHITE ROACH. Beds of Limestone .. .. ft. in. *c* Limestone, with a parting at 4 inches from the bottom of the bed, and a 1-inch band of ferruginous Alum-shale at the base. Ostrea .. .. 2 3 *b* Shell-Limestone .. .. 1 0 *a* Grey Shell-Limestone, 10 inches thick, passing into a band of harder, blue, Shell-Limestone 1 3	4	6
	INTERMARINE BEDS.		
57, 56	LEANING or "LANING" VEIN. Two beds of hard shelly-Limestone, separated by a 1-inch parting. Corbula.	5	6
55	ROYAL LIMESTONE	5	0
54	RED RAG. Bed of hard Limestone. Fish and Turtle. Ostrea.	2	2
53	RAG. Green shaly Marl	1	0
52	UNDER RAG. Limestone made up chiefly of broken shells. Paludina.	1	6
51	Greenish Shales. Ostrea	1	9
50	FREESTONE VEIN. Chiefly Limestone, as below :— *i* TOP SHINGLE. Bituminous sandy Limestone. Fish-remains, &c. *h* SHINGLE. *g* UNDER-PICKING. Thinly-laminated sandy Shale. Plant-remains. Archæoniscus, Fish, Cyrena. *f* LOWER SHINGLE. Rubbly Limestone. *e* CRAB. *d* ROACH, Hard and compact Shell-Limestone, with Paludina, Melania, &c. *c* SUGAR BED. *b* FREESTONE BED. Compact, sandy, grey Limestone. Ostrea. Fish, &c. (*Lepidotus minor*). *a* BLUE BED. Bluish Limestone.	16	0

SECTION OF PURBECK STRATA OF DURLSTON BAY—*continued.*

No. of Bed.	Character of Rock and Organic Remains.	Thickness.	
		ft.	in.
49	LIAS BEDS. Limestone and Shale .. .. *c* Alternations of Black and Brown Clay with hard bands of Limestone. Cypris. Fish-remains (measured in Quarry in the Cliff). *b* Soft, bituminous, cream-coloured Limestone, with a little cherty flint. *a* Black shale of variable thickness (3 inches).	2	11
48	LIAS RAG. Hard shelly-Limestone. Plant-remains. Cypris, Cyrena, &c.	2	4
47	Dark sandy Marl (a white efflorescence on exposure) with much carbonaceous and green matter in the lower part. Cypris, &c.	1	4
46	LAPER and UNDER-PICKING. Impure sandy Limestone (containing green matter) with Shaly partings and a few seams of Beef in the lower part. Serpula, Cyclas, Cyrena, Fish-teeth, &c. At 2 feet the upper surface of the bed is covered with pentagonal dry-surface markings.	3	0
45	UPPER TOMBSTONE BED, BRASSY BED, AND LOWER TOMBSTONE BED. ft. in. *d* Thick bed of Shell-Limestone. The surface of the bed covered with scratches in directions 15° W. of North, and 5° E. of North. Melanopsis. Fish (Microdon radiatus, Hybodus strictus, Lepidotus minor). Turtle (Pleurosternon concinnum). Pterodactyle, Crocodile (Macrorhynchus), &c. .. 2 9 *c* Pale-blue Marl .. .. 0 3 *b* Shaly Shell-Limestone .. .. 0 3 *a* Soft black Shales 0 3	13	6
	CINDER BEDS.		
44	*Soft Cinder Bed* (a hard band, 3 inches thick, occurs on the top of the bed), dark-grey mass of Ostrea distorta.	3	9
43	*Hard Cinder Bed.* Ostrea distorta, less numerous and more disseminated than in the bed above. Hemicidaris Purbeckensis (Forbes) Cardium Gibbsii, Serpula, Perna, Trigonia, Fish-remains, &c.	4	9
	CHERTY FRESHWATER BEDS.		
42	FEATHER QUARRY. Thin bands of impure Limestone in sandy Shale. Cypris, Cyrena.	0	9
41	BUTTON BED. Sandy, hard, bituminous, shelly Limestone-bands with shaly partings, and occasionally chert in the upper part.	9	7

Section of Purbeck Strata of Durlston Bay—*continued.*

No. of Bed.	Character of Rock and Organic Remains.	Thickness. ft.	Thickness. in.
40	Feather Bed. Hard, bituminous, pinkish Limestone, crowded with shells. Fragments of Cyrena. Reptiles (Nothetes destructor, &c.).	2	2
39	Indurated Marl, with remains of Insects ..	0	4
38	Under Feather-bed. Irregular, compact Shell-Limestone of variable thickness.	0	8
37	Shale	1	9
	ft. in. *b* Pale, sandy Shale .. .. 0 9 *a* Brown, bituminous Shale, with a thin band of Chert at the base 1 0		
36	Cap Bed. Bituminous and argillaceous, hard and irregular Limestone. Cyrena.	1	0
35	Sly Bed. Soft, black, bituminous shale (with a white efflorescence on exposure). A hard calcareous band near the base. Cyrena, Fish, Turtle.	2	0
34	New Vein (Upon 5 Bed—Under 5 Bed—Tombstone Bed). Hard and compact beds of Shell-Limestone with shaly bands and 2 inches of soft, black, calcareous shale at the base. Corbula, Melania.	4	1
33	Shear Bed. Hard bands of impure Limestone with ripple-marks.	0	4
32	Shale, Limestone and Marl (as under)	1	4
	c Sandy Shale .. .. 0 4 *b* Shelly Limestone .. .. 0 3 *a* Shale, occasionally Marl. Cyrena 0 9		
31	Flint Bed. White, bituminous, marly Limestone, with irregularly-disseminated black cherty flints. The lower 12 inches is shaly, and the under side of the bed is covered with markings in relief, which are casts of the cracked surface of the bed below. The fossils (chiefly univalves) are numerous and well-preserved; Paludina; Valvata; Physa; Planorbis; Cyrena, &c.	3	0
30	Bands of sandy, calcareous Shale and indurated Marl, with thin seams of chert about the middle of the bed. At the outcrop on the top of the cliff, this bed and the bed beneath pass into a marly cream-coloured Limestone, with chert in the upper part. Fossils.	2	8
29	Hard, grey, shelly, and bituminous Limestone (1 to 2 inches). Cyrena.	0	2

SECTION OF PURBECK STRATA OF DURLSTON BAY—*continued.*

No. of Bed.	Character of Rock and Organic Remains.			Thickness.	
		ft.	in.	ft.	in.
28	Blue shaly Marl			1	0
27	Soft, black, carbonaceous Shale, 10 inches, with an irregular band of black chert at the base of the bed from 0 to 2 inches thick; thin seams of beef, selenite, crushed shells. Insects, Fish, &c.			1	0
26	WHITE PUT. Alternations of sandy, shaly, and indurated Marls, with a band of irregular Shell-Limestone, and a band of chert 2 inches above the base of the bed. Fish, Insects, Cyrena, &c.			3	3
25	Cherty and hard blue Shell-Limestone. Corbula, Cyrena, Paludina.			1	0
	MARLY FRESHWATER BEDS.				
24	Soft Marls, passing into white, compact Marl ..			3	6
	c Shaly Marl. Fish	1	0		
	b Soft grey Marl. Cypris	1	6		
	a Compact white Marl	1	0		
23	Limestone and Marl			0	10
	b Hard, bituminous, cherty Limestone 3 in. to	0	5		
	a Shaly Marls with fossils at the base. Fish ..	0	6		
22	*Black and brown carbonaceous Shaly Bed*, with occasional thin chert and seams of beef, of variable thickness, filling inequalities in the bed below. Selenite and vegetable remains, with Cypris; Valvata; Paludina; Rissoa; Physa Bristovii; Limnæa; Planorbis; Reptiles (Macellodus Brodiei); Insectivorous marsupial Mammals (Spalacotherium Tricuspidens, &c., &c.).			0	11
21	*Compact Marl* (as under)			8	2
	g Hard, pale, compact Marl	0	10		
	f Bands of impure shelly Limestone ..	0	2		
	e Hard pale Marl	0	8		
	d Bands of impure shelly Limestone ..	0	2		
	c Compact grey Marl	3	0		
	b Compact blue Marl	1	0		
	a Hard and compact pale-grey Marl 18 in.	2	4		
20	Shale and Limestone (as under)			1	3
	c Brown sandy Shale	0	5		
	b Hard, impure Grey Limestone. Fish ..	0	6		
	a Soft Shale	0	4		
	Note.—The Middle Purbecks are characterised by the presence of Cypris striato-punctata, C. fasciculata and C. granulata.				

SECTION OF PURBECK STRATA OF DURLSTON BAY—*continued.*

No. of Bed.	Character of Rock and Organic Remains.	Thickness.	
		ft.	in.
	LOWER PURBECK BEDS.		
	SOFT COCKLE BEDS.		
19	Hard and soft Marls (as under) .. .. Scales of Nothosomus. Insects (Wings of Libellula, Neuroptera, Homoptera, Lepidoptera). Archæoniscus Brodiei. Carbonaceous specks. Pseudomorphous crystals of Rock Salt. These beds undulate and become thicker in the upper part of the cliff. ft. in. Hard and soft Marl .. .. 3 4 Soft Marls .. .. 4 0 Hard and soft Marls—mostly hard .. .. 6 0 Soft grey Marls .. .. 3 6 Grey Marl .. .. 2 0 Harder grey Marl .. .. 3 0 Soft blue Marl. Fish .. .. 1 6 Harder grey Marl .. .. 3 0 Soft blue Marl .. .. 1 6 Hard pale Marl .. .. 3 0 Soft pale Marl .. .. 1 0 Hard pale Marl .. .. 3 6 Blue Marl .. .. 2 0 Hard white Marl .. .. 1 10 Soft blue Marl 2 2	41	4
18	Grey shaly Marls with sandy laminæ below ..	2	4
17	Band of BRECCIATED LIMESTONE. Leda, &c.	0	2
16	Dark-grey marly Shale, or shaly Marl, becoming harder and more marly towards the lower part.	3	10
15	Hard pale Marl	2	0
14	Hard band of bituminous BRECCIATED LIMESTONE, containing pseudomorphous crystals of Rock Salt, with Plant- and Insect-remains.	0	2
13	*Soft, blue shaly Marls,* containing Univalve shells. Gypsum (satin spar). Large botryoidal masses 10 to 20 feet in diameter are quarried in the cliff and used for making Plaster of Paris.	32	3
	HARD COCKLE BEDS.		
12	*Pale blue marly Limestone, and blue marly Shales.* In the upper bed small round cavities occur, lined with minute crystals of calcite. Cardia; Insects, &c.	10	0
	CYPRIS FREESTONE.		
11	*Beds of blue marly Shale and marly Limestone (chiefly shale),* which towards the base abounds with Cypris.	11	0

SECTION OF PURBECK STRATA OF DURLSTON BAY—*continued.*

No. of Bed.	Character of Rock and Organic Remains.	Thickness.	
		ft.	in.
10	*Blue Marl*	0	3
9	*Soft, grey Cypris-Shales* with harder marly bands.	15	0
8	*Impure Limestone and sandy Shales;* the former with carbonaceous specks and cavities filled with calcite.	6	0
7	*Olive-brown Marlstone.* Archæoniscus, &c. ..	4	0
	BROKEN BANDS.		
6	*Thin slaty beds of bituminous sandy Limestone,* much broken and squeezed together, with a few broken fragments of chert. Cypris abundant.	15	0
	SOFT CAP.		
5	*Impure, brown, bituminous Limestone* (the beds cracked and full of small fissures and cavities), with bands of chert and broken fragments.	5	0
	HARD OR SKULL CAP.		
4	*Limestone and Shale*	2	6
3	*Very irregular bed of hard, brown, bituminous Limestone.*	1	0
2	*Irregular beds of brown, bituminous Limestone* ..	10	0
1	*Parting* of Dirt, or ancient surface-soil (Dirt Bed or Black Dirt).		
	Note.—The Lower Purbecks are characterised by the occurrence of Cypris Purbeckensis and C. punctata.		
	PORTLAND STONE.		
	The total thickness of the Purbeck Beds, as measured by Mr. H. W. Bristow at Durlston Bay, is 389 feet; at Warbarrow Bay, 290 feet; at Mewps Bay, 253 feet; at Lulworth Cove, 179 feet, as measured by Messrs. H. W. Bristow and W. Whitaker; and at Ridgway Railway-cutting, 188 feet, as measured by the Rev. O. Fisher and Mr. H. W. Bristow.		

Of the fossils found in the cliffs of Durlston Bay, the most remarkable are Mammalian remains, first discovered by the late Mr. W. R. Brodie in the dirt bed or thin bed of marl, of the Middle Purbeck, but since then in larger numbers by Mr. S. H. Beckles. The importance of the discovery may be judged from the fact that the entire number of previously known fossil Mammalia from all the beds, older than the Tertiaries, was but five, not one species having been recorded between the years 1818 and 1854. Further additions may be expected to the list, as the area over which Mr. Beckles' operations were conducted did not exceed 500 square yards, and the stratum was but a few inches thick.

The value of the collection, which consists chiefly of fragments of jaws and some other small bones, was not fully realised until Mr. William Davies, the assistant curator of the British Museum, with his well-known skill, united the fragmentary portions; the restored specimens, with subsequent discoveries, now include 28 species of 15 genera.

LIST OF REPTILIAN REMAINS, AND REMAINS OF INSECTIVOROUS MARSUPIAL MAMMALS from the Purbecks of Durlston Bay.*

Amblotherium soricinum, Owen.
Achyrodon nanus, Owen.
 „ *pusillus*, Owen.
 „ *major*, Owen.
Amphitherium Prevostii, Cuvier.
Bolodon crassidens, Owen.
Leptocladius? dubius, Owen.
Plagiaulax Falconeri, Owen.
 „ *medius*, Owen.
 „ *minor*, Falconer.
 „ *Becklesii*, Falconer.
Peralestes longirostris, Owen.
Peramus tenuirostris, Owen.
 „ *minor*, Owen.
Peraspalax talpoïdes, Owen.
Phascolotherium Bucklandi, Owen.

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* For a description of these discoveries, see Prof. Owen, 'Quart. Journ. Geol. Soc.,' vol. x. p. 420 (1854); and 'Fossil Mammals of the Mesozoic Formations,' Pal. Soc., 1871.

Stylodon robustus, Owen.
„ *pusillus*, Owen.
Spalacotherium tricuspidens, Owen.
„ *minus*, Owen.
Triacanthodon serrula, Owen.
Triconodon ferox, Owen.
„ *occisor*, Owen.
„ *major*, Owen.
„ *mordax*, Owen.
„ *sp. indit*, Owen.

With the Mammalian remains occur those of Insects and small Lizards on which they are thought to have fed. Among them are also several species of small Quadrupeds which resemble forms existing in Australia. This collection, purchased by the British Museum, is set out in one of the Table-cases at the north end of the Palæontological Gallery.

In the summer of 1881 Mr. Willett directed operations in the cliff so successfully explored by Mr. Beckles. The result was the discovery of a jaw, with teeth *in situ*, of *Triconodon mordax*; and Crocodilian remains consisting of *Theriosuchus pusillus*, *Nannosuchus gracilidens*, and *Nuthetes destructor*; with a few other Mammalian and Reptilian fragments not easily determinable; but no new species appears to have been discovered.*

At Swanage it is rather in the quarries, than the cliff, that the remains of fish and turtle have been discovered. The quarries (not being open, as at Portland, but worked through shafts and galleries, shut out from the light) cannot be explored by the public, and fossils can only be found underground by the workmen or in the quarried stone brought to the surface. These quarries furnish the well-known Purbeck paving-stone.

Of the fishes and turtles of the Swanage beds there is in the Dorset County Museum a fine collection made by the late Dr. Willcox, of Swanage, and of which the following is a list :—

FISHES.

Asteracanthus verrucosus, Egerton.
„ *semiverrucosus*, Egerton.

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* 'Quart. Journ. Geol. Soc.,' vol. xxxvii. p. 376 (1881).

Aspidorhynchus Fisheri, Egerton.
Histionotus angularis, Egerton.
Hybodus.
Lepidotus major, Eg.
„ *minor*, Ag.
Microdon radiatus, Agassiz.
Ophiopsis breviceps, Eg.
„ *dorsalis*, Ag.
Pholidophorus granulatus, Eg.
„ *ornatus*, Ag.
Pleuropholis attenuatus, Eg.

And some undetermined species.

Reptilia.

Chelone obovata, Owen.
„ *planiceps*, Owen.
Pleurosternon concinnum, Owen.
„ *emarginatum*, Owen.
„ *latiscutatum*, Owen.
„ *ovatum*, Owen.
Tretosternon punctatum (*T. Bakewelli*, Mant. sp.), Owen.
Goniopholis crassidens, Owen.

The celebrated collections of Fossil Fishes made by the Earl of Enniskillen and Sir Philip Egerton, and lately acquired by the British Museum, contain the following species from the Dorsetshire "Purbecks":—

Aspidorhynchus Fisheri, Egerton.
Asteracanthus semiverrucosus, Egerton.
„ *verrucosus*, Egerton.
Histionotus angularis, Egerton.
Hybodus dorsalis, Agassiz.
„ *strictus*, Agassiz.
Megalurus Austeni, Egerton.
„ *Damoni*, Egerton.
Ophiopsis dorsalis, Agassiz.
„ *penicillatus*, Agassiz.
Pholidophorus granulatus, Egerton.
„ *ornatus*, Agassiz.

Pleuropholis attenuatus, Egerton.
" *crassicaudus*, Egerton.
" *longicaudus*, Egerton.
" *serratus*, Egerton [Hartwell].

Mr. J. O. Westwood's "Contributions to Fossil Entomology," ('Quart. Journ. Geol. Soc.,' vol. x., p. 378) contain descriptions of the Insects found in the Dorsetshire Purbecks, a collection of which is in the County Museum. In the same volume, page 475, is a communication by the Rev. P. B. Brodie, "On the Insect Beds of the Purbeck Formation in Wiltshire and Dorsetshire."

Though entire Fishes are now of rare occurrence, teeth and scales are largely diffused. *Cyprides*, *Cyclades*, and other Freshwater forms prevail in particular beds, frequently in masses. *Hemicidaris Purbeckensis* occurs in the Cinder Bed, and, together with *Ostrea distorta* and *Serpula*, largely contributes to form this singular mass. From its greater thickness and tenacity, this bed is the most prominent, both *in situ* and in fallen blocks on the shore. Though the two "Dirt beds" are present, they contain no Coniferæ or Cycadeæ, which are so numerous in the Purbeck Beds of Portland. Fragments of Lignite occur in the stony beds. Nodules of Chert and Flint, in layers, occur in the Purbecks.

At the base of the cliff approaching Peveril Point, large lumps of gypsum occur, which at one time was a marketable material, worth from 15*s*. to 20*s*. a ton.

From the greater depth of the best stone beds the Swanage quarries are not open workings, but are approached by means of an inclined shaft, to the depth of a hundred or more feet. This, in the judgment of the Government Inspector of Mines, constituted a right of inspection.*

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* Dr. C. le Neve Foster, Her Majesty's Inspector of Mines, says in his report for 1877, p. 446: "The Purbeck stone is a new feature in my statistics. In spite of a great many difficulties, I believe I have at last attained a fairly correct statement of the total amount raised from *mines*. There are nearly a hundred stone-mines in the Swanage district, worked by one, two, or three men underground, who are in many cases the owners as well as the occupiers. Their work is often most irregular; if the men can find work as masons, they abandon their quarries for a time, and do not return to them till other work is slack. As the

HASTINGS SANDS. Estimated thickness, 2000 feet.

The conspicuous coloured cliffs north of the town are formed of the lower division of the Wealden series; they consist of variegated sands and clays, with occasional bands of ironstone, and masses of calciferous grits, and appear in striking contrast to the white chalk cliffs beyond. The fauna and flora of the Hastings Sands, in common with other parts of the Wealden, are chiefly terrestrial, and contain here but few organic remains. Bones of *Iguanodon* and other gigantic reptiles are not unfrequent, together with pyritised cones and other seed-vessels; also *Thuytes Kurrianus*, Mant. Numerous other Reptilian remains, including the *Pterodactyle*, or flying lizard, also turtles and fishes, have been discovered in the south-east of England, and in the Isle of Wight. The Wealden of North Germany contains many plants and vegetable remains, which have been described by Dr. Dunker, of Hesse Cassel. The freshwater shell *Cyrena media* is abundant in the Wealden at Swanage.

PUNFIELD FORMATION.

At Punfield Cove the upper part of the Wealden is separated from the Lower Greensand by *fluvio-marine* beds, which until lately, have been absorbed in the Wealden. The fossil remains are of *Marine*, *Freshwater*, and *Terrestrial* origin, and bear in this respect a similar relation to the Upper Wealden that the Purbecks do to the Lower. The peculiar character of the Punfield fossils had

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quarrymen of the Isle of Purbeck had never been troubled with Government forms till this year, I had considerable difficulty in getting returns from them. Endless mistakes were made, requiring investigation by correspondence, and I may safely say that the 92 stone mines near Swanage, employing only 264 persons, gave me more trouble than all the other mines of my district put together. No doubt I shall have very much less inconvenience in future years, as the men will soon get into the way of filling up the returns correctly." The following figures represent the number of tons raised during the year 1877:—Potters' Clay and other Clays: Furzy Ground, 10,759 tons; Seymours, 8980 tons—total, 19,739 tons. Purbeck stone and marble, dressed, 11,816 tons 10 cwt. Purbeck stone, undressed, 1411 tons 10 cwt. Cement Stone: Kimeridge Mine, 1431 tons.

long since attracted the attention of Prof. E. Forbes, Mr. Godwin-Austen, and others; but it was reserved for Prof. J. W. Judd,* by comparison with corresponding beds in England and the Continent, to tabulate the strata into a separate formation.

Section of the Punfield Formation, N. side of Swanage Bay, as given by Prof. Judd. (See Fig. 2, p. 213 of his Memoir.)

"Lower Greensand" (Upper Neocomian).
Grey cypridiferous shales, with bands of limestone (*Cyrena*, &c.), "beef."
Cream-coloured and yellow sands, passing into thick irregularly bedded ironstones.
Ash-coloured and yellow sands, with seams and bands of ironstone (*Oyster-beds*).
Grey and ash-coloured sandy clay, with bands of ironstone.
Bright yellow sands passing into ironstone.
Whitish and carbonaceous clays.
Ash-coloured and yellow sands, with thin irregular wavy seams of light- and dark-blue clay, and bands and patches of imperfect brown ironstone.
Ash-coloured and yellow sands, with thin irregular wavy seams of light- and dark-blue clay, and bands and patches of lignite and imperfect brown ironstone.
Marine band.
Variegated beds of the Wealden.

LIST OF FOSSILS FROM THE MARINE BANDS OF PUNFIELD, GIVEN BY PROF. JUDD. (See p. 215 of his Memoir.)

Teeth of Lamna, sp.
 „ *Pycnodus*, sp.
Ammonites Deshayesii, Leym.
Vicarya pizcuetana, Vilanova, sp.
 „ *Lujani*, De Verneuil et Collomb.
 „ *Pradoi*, De Verneuil et De Lorière.
Cerithium Vilanovæ, De Verneuil et De Lorière.
 „ *Pailleti*, De Verneuil et De Lorière.
Turritella Tournali, H. Coquand.

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* "On the Punfield Formation," 'Quart. Journ. Geol. Soc.,' vol. xxvii. p. 207.

Mr. C. J. A. Meyer (*ibid.*, vol. xxviii. p. 243) takes a different view of the relation of these beds.

Pleurotoma Utrillasi, De Verneuil et De Lorière.
Fusus ? neocomiensis, D'Orb.
Actæon Esqueræ, De Verneuil et De Lorière.
„ *pradoana*, De Verneuil et De Lorière.
Actæonella oliviformis, H. Coquand.
Trochus Esqueræ, De Verneuil et De Lorière.
Natica lævigata, Desh. sp.
„ *pradoana*, Vilanova.
Neritopsis minima, De Verneuil et De Lorière.
Orthostoma Verneuili, Vilanova, sp.
Exogyra Boussingaulti, D'Orb.
„ *sinuata*, Sow. (dwarfed).
Anomia lævigata, Sow.
Plicatula asperrima, D'Orb.
Perna Rauliniana, Pictet et Roux.
Modiola giffreana, Pictet et Roux.
Arca cymodoce, H. Coquand (young).
Arca, sp.
Cardium subhillanum, Leym.
„ *impressum*, Desh.
Astarte, sp.
Isocardia nasuta, H. Coquand.
„ sp.
Leda scaphoides, Pictet et Campiche.
Tellina ? gibba, H. Coquand.
Corbula striatula, Sow.
Pholadomya semicostata, Ag.
Pholadidea (borings).
Serpula.
Numerous small univalves and bivalves, fragmentary and undeterminable.
Much wood and carbonaceous matter.

Many of the above are new to Great Britain.

Though the section is much obscured by *débris* and vegetation, the marine bed is easily recognised, as, from its hardness and continuity, it shelves out half-way up the cliff in a grey compact mass (weathering brown), composed of *Ostrea* and other broken shells, in texture between the Cinder Bed and the Purbeck Marble. Another section of the Punfield beds is visible at Worbarrow Bay.

CHALK.

North of Swanage Bay to the Foreland, the Chalk layers present the same irregular character as at Mewps Bay (Weymouth side), being vertical on the left or south side, while on the north they are horizontal, and curved at their junction. The sea has so acted on this line of cliff as to detach columnar masses and pinnacles of chalk harder than the rest, the most conspicuous of which is known by the name of "Old Harry." Numerous caverns have also been worn in the cliff. These conditions have their counterpart on the opposite coast of the Isle of Wight in the remarkable curved strata of Scratchell's Bay and the Needles. But few fossils occur in the chalk cliffs of Swanage Bay.

TERTIARY.

Plastic Clay or Woolwich series. (*Lower Eocene.*)

Continuous with the Chalk cliffs, and forming the southern boundary of Studland Bay; these beds are charged with iron, to which they owe their bright and varied colours, as at Alum Bay.

I am not aware of any fossils being found here, though in the equivalent beds at Woolwich, Reading, and other places they contain a mixture of marine and freshwater shells.

Lower Bagshot Sands and Clay.

The shore at Studland Bay and coast beyond forms the eastern boundary of this series. Leaves of Dicotyledonous Plants are numerous in the white clay beds and sands east and west of Bournemouth, and which have also yielded other plants, abundant in genera and species, bearing affinity to the sub-tropical flora of Australia and India.

The notable block of sandstone, the Agglestone, overlooking Studland Bay, is a product of the Bagshot series. The softer portions of the sandstone having been denuded away by atmospheric action, the harder concretionary mass has been left standing as we now see it. The Lower Bagshot Beds extend over a large part of Dorset, north and west of Studland, where, the soil being thin, the agricultural value of the land is low, and it remains in many places an uncultivated heath.

The new railway from Wareham to Swanage gives a good section of Drift Gravel over Lower Bagshot Sand at the junction with the main line. Thence to Corfe there are cuttings in the sands and clays of the Bagshot Series, the latter sometimes lying in hollows of the former. At Corfe the line cuts through the Chalk, which is there very hard, and with a mass of gravel over it on the north. From Corfe to Swanage there are many cuttings in the variously coloured clays and sands of the Wealden Series; but the line nowhere touches the Purbeck Beds. The work is not yet finished.

BRIDPORT.

Inferior Oolite.

West of Abbotsbury to Burton Cliff, one mile east of Bridport Harbour, the coast offers no feature of geological interest. Shingle and Æolian or blown sand, as indicated in the map of the Geological Survey, form the coast-line between these two points.

At Burton Cliff the sands of the Inferior Oolite occupy an isolated position, but reappear in the very fine section displayed in perpendicular cliffs 200 feet high, east of Bridport Harbour. This formation, which is of a uniform character, consists of iron-shot, fox-coloured sands, with layers of hard calcareous bands, curiously weathered. The whole series is very poor in fossils. These beds come to the surface again at West Cliff on the west side of the Harbour, being faulted against the Fullers' Earth and Forest Marble; the entire thickness of the section here is estimated by Dr. T. Wright at about 400 feet. These sands, together with the Cephalopoda Bed—which (especially in West Dorset and Somerset) is distinguished by the importance, both as regards number of species and individuals, of *Ammonites*, *Nautili*, and *Belemnites*, which it has been found to contain—have been coloured on the maps of the Geological Survey in accordance with the views of Dr. Thomas Wright, by whom they were referred to the Upper Lias—and who remarked that "the Cephalopoda-bed contains a number of well-known Liassic *Ammonites*, *Nautili*, and *Belemnites*, and that the weight of palæontological evidence is in favour of the supposition, that it belongs to the Lias, rather than to the Oolite formation." In other words, that the "Cephalopoda-bed was the close of the Liassic, and not the commencement of the Oolitic period."* Prof. John Phillips, considering the Dorsetshire or Bridport Sands as intermediate between the Upper Lias and the Inferior Oolite, named them "Midford Sands," Midford near Bath being the spot where they were first denominated by William Smith as the sand of the Inferior Oolite.

Prof. Buckman's views accord with those of the Geological Survey; only, "that, while the Gloucestershire Cephalopoda-bed is at the base of the Inferior Oolite, or top of the Upper Lias, the Dorset Cephalopoda-bed is near the top of the former;" and "this position has been supported by the *similarity*, not the identity, of the Cephalopods, which, indeed, have been held to point to Lias rather than to Oolite."†

Mr. H. W. Bristow, who surveyed and mapped much of the Oolites of Gloucestershire and Somersetshire, and nearly all the Oolitic strata of Dorsetshire, is of opinion that there are two distinct but conformable deposits of sand in the southern extension of the Inferior Oolite. The upper sands with occasional thin and interrupted beds of limestone, and the sandy limestones of Ham Hill, he believes to represent the lower part of the Inferior Oolite Limestone of the Cotteswolds; while the underlying sands seen in the road-cutting on the east side of Yeovil are on the same horizon as the sands of Midford near Bath.

These last form the natural base of the Inferior Oolite series, and belong stratigraphically to the Inferior Oolite rather than to the Upper Lias.

At Eype Cliff the Middle Lias is well shown, capped further west, at Thorncombe Beacon and Down Cliff, by Upper Lias and Midford Sands. Detached blocks at the base of the cliff yield many fossils of the Upper and Middle Lias; one bed of grey micaceous sandstone has yielded many specimens of *Ophioderma tenuibranchiata*, Forbes.

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* "On the Palæontological and Stratigraphical relations of the so-called Sands of the Inferior Oolite," by Dr. Thomas Wright, 'Quart. Journ. Geol. Soc.' for 1856, vol. xii. p. 292.

† "On the Fossil Beds of Bradford Abbas and its Vicinity," 'Proc. Dorset Nat. Hist. and Antiq. Field Club,' vol. i. p. 64, 1877, by Prof. James Buckman. See also "The Cephalopoda-Beds of Gloucester, Dorset, and Somerset, by the same author, 'Quart. Journ. Geol. Soc.,' vol. xxxiii. p. 1, 1877.

Other fossils found in the detached blocks are:—*Ammonites margaritatus* (small specimens only, but numerous); *Pentacrinus* columns (probably *P. gracilis*); *Avicula* (two species); *Modiola Sowerbyana*; also portions of *Ammonites*, *Nautili*, and *Belemnites* of undeterminable species.

In the valley-slopes of Chideock and Eype there are large deposits of Chalk-flints.

The numerous quarries in the Inferior Oolite of Burton Bradstock formerly yielded a rich harvest of fossils; but of late years the "ragstone," which is only adapted for rough purposes, has been little in demand.

LIST OF THE MORE ABUNDANT FOSSILS FROM THE INFERIOR OOLITE OF BRIDPORT AND BURTON BRADSTOCK.

CEPHALOPODA.

Ammonites Aalensis, Ziet.
" *Brongniarti*, Sow.
" *Brocchii*, Sow.
" *dimorphus*, D'Orb.
" *Gervillii*, Sow.
" *Hollandæ*, S. Buckman.
" *Humphresianus*, Sow.
" *Martinsii*, D'Orb.
" *Ooliticus*, D'Orb.
" *Parkinsoni*, Sow.
" *polymorphus*, D'Orb.
" *subradiatus*, Sow.
" *serpentinus*, Rein.
" *Truellii*, D'Orb.
" *variabilis*, D'Orb.
Nautilus lineatus, Sow.
" *excavatus*, Sow.
Belemnites giganteus, Schloth.
" ?
Ancyloceras annulatum, Desh.
" *Waltoni*, Mor.

GASTEROPODA.

Alaria Phillipsii, D'Orb.
Euomphalus tuberculosa, Thorent.
Buccinum ?
Natica ?
Cirrus nodosus, Sow.
Pleurotomaria elongata, Sow.
„ *ornata*, Defr.
„ *proteus*, Desl.
„ *pallium* (*ornata*, Sow.).
„ *punctata*, Sow.

CONCHIFERA.

Astarte modiolaris, Lam.
„ *obliqua*, Desh.
„ *ungulata*, Phil.
Exogyra.
Lima notata, Munst.
„ *semicircularis*, Goldf.
Hinnites tenuistriatus, Munst.
Modiola minima, Sow.
Myacites Jurassi, Brong.
Nucula.
Opis trigonalis, Sow.
Pecten lens, Sow.
„ *læviradiatus*, Waagen.
„ *cornutus*, Quenst.
„ *demissus*, Phil.
Pinna.
Trigonia costata, Sow.
„ *striata*, Sow.
„ *tenuicosta*, Lyc.

BRACHIOPODA.*

Terebratula Phillipsi, Morris.
„ *Stephani*, Dav.

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* "The Brachiopoda from the Inferior Oolite of Dorset and a portion of Somerset," by S. S. Buckman, 'Proc. Dorset Nat. Hist. and Field Club,' vol. iv. p. 1.

Terebratula (abundant) *sphæroidalis*, Sow.
„ *decipiens*, E. Desl.
„ *Waltoni*, Dav.
Waldheimia anglica, Oppel.
„ *carinata*, Lam.
Rhynchonella senticosa, V. Buch.
„ *spinosa*, Schloth.
„ *cynocephala*, Rich.

ECHINODERMATA.

Collyrites ringens, Ag.
„ *bicordatus*, Desor.
Clypeus altus, McCoy.
Cidaris Bouchardi, Wright.
Echinus bigranularis, Lam.
Holectypus depressus, Lam.
„ *hemisphericus*, Desor.
Nucleolites Agassizi, Wright.

Quarries at Powerscourt, Loders, and other places inland, and north of Bridport, yield fossils of the same general character as the above.

The Rev. G. F. Whidborne, M.A., in "Notes on some Fossils, chiefly Mollusca, from the Inferior Oolite," describes several new species and refers to others found at Burton Bradstock, 'Quart. Journ. Geol. Soc.,' vol. xxxix. p. 487 (1883). In the same volume (p. 541) are descriptions of fossil sponges from the Inferior Oolite by Prof. W. J. Sollas. The following are referred to Burton Bradstock: — *Mastodictyum Whidborni*, *Leptophragma fragile*, *Plectospyris major*, *Calathiscus variolatus*, *Platychonia elegans*, *Peronella Metabronnii.*

The Cephalopoda and other Fossils which distinguish the Inferior Oolite beds of Dorsetshire, are principally from the rich localities of Bradford Abbas—Halfway House, near Sherborne, and the district around Yeovil. Many of these have been described by Prof. Buckman and Mr. S. S. Buckman in the 'Quart. Journ. Geol. Soc.,' and in the 'Proceedings of the Dorset Nat. Hist. and Field Club.'

The list of Fossils from the Inferior Oolite of Dorset has been enriched by the discovery of the lower jaw and other portions of the head of *Megalosaurus Bucklandi*, Meyer, found by Mr. Cleminshaw in the freestone of the Inferior Oolite, near Sherborne, and now in the Museum of the Sherborne Grammar School. This specimen is the subject of a Paper by Prof. Owen, read April 25, 1883, 'Quart. Journ. Geol. Soc.,' vol. xxxix. p. 334, Plate xi. (1883).

FULLERS' EARTH.

Overlying, and faulted against, the Sands of the Inferior Oolite, this formation is represented at West Cliff, west of Bridport Harbour, by a thick bed of grey marl, which may also be recognised by the following fossils:—

Avicula echinata.
Ceromya concentrica, Sow.
Gervillia.
Goniomya.
Modiola minima, Sow.
Ostrea acuminata.
  „ large flat species.
Pecten hemicostatus.
  „ *lens.*
Pholadomya carinata, Munst.
Rhynchonella farcta.
  „ *varians.*
Terebratula globata.
  „ *ornithocephala.*
Trigonia, clavellated form.
  „ *costata.*

Also numerous species of small shells, corals, &c., on flagstones, Lignite, and Pyrites.

FOREST MARBLE.

This formation is nowhere better developed than at Bothenhampton, a village one mile east of Bridport Harbour, where, in a large open quarry, the beds of hard shelly limestone are worked for paving- and building-purposes.

SECTION AT BOTHENHAMPTON QUARRY.

Grey and other light-coloured Clays	6 feet.
Yellowish and grey stone, bedded and cross-bedded from 1 inch to 18 inches in thickness—the surfaces of the beds covered with comminuted shells, &c. ..	25 „
Clay at base, of varying thickness.	
Greatest depth of quarry	42 „
The beds dip inland.	

West of Bridport Harbour the cliff is capped with Forest Marble, corresponding, where exposed, with the beds at Bothenhampton.

LIST OF FOSSILS found here and at BOTHENHAMPTON.

Avicula costata, Sow.
Lima duplicata, Sow.
„ *cardiiformis*, Sow.
Modiola Lonsdalei, Lyc.
„ *minima*, Sow.
Mytilus.
Ostrea.
Pecten arcuatus, Sow.
„ *lens*, Sow.
Perna.
Terebratula obovata, Sow.
„ *intermedia*, Sow.
„ *digona*, Sow.
Rhynchonella varians, Schloth.
Apiocrinus rotundus, Miller.
Acrosalenia hemicidaroides, Wright.
„ *spinosa*, Ag.
Echinobrissus clunicularis, Llhwyd.
Holectypus depressus, Leske.
Bones of Dinosaur.

Numerous flagstones, composed of cemented masses of broken shells. At Chideock there are cliffs and quarries of Inferior Oolite rich in Fossils, of species similar to those of Burton Bradstock. The Lias formation of Charmouth and Lyme Regis forms the western extremity of the coast of Dorsetshire. The following are some of the publications which relate to the Geology of this celebrated locality.

E. C. H. Day, "On the Middle and Upper Lias of the Dorsetshire Coast," 'Quart. Journ. Geol. Soc.,' vol. xix. p. 278 (1863).

H. T. De la Beche, "On the Lias of the Coast in the vicinity of Lyme Regis, Dorsetshire," 'Trans. Geol. Soc.,' 2nd Ser. vol. ii. p. 21.

Dr. Buckland, "Bridgewater Treatise," vol. ii., for description and figures of some of the more remarkable fossils of the Lias of Dorsetshire.

NOTE.—The Inferior Oolite on the coast of Normandy, opposite to that of Dorsetshire, is characterised by the number and variety of its fossils, many of which are common to both sides of the Channel. Dr. H. Woodward and myself, with Prof. Deslongchamps, spent some time in examining the collection formed by M. Carabeuf, from the Oolitic beds of Bayeux and Caen, and we were of opinion that for variety and state of preservation the collection was unrivalled. It has since been purchased by Prof. Deslongchamps, and forms the materials for his Memoir on the Fossils of the Inferior Oolite of Normandy, now in course of publication, though slow in its issue.

The following notes, contributed by Mr. R. Etheridge, F.R.S., with the accompanying vertical section, illustrate the structure of the coast west of the Chesil Bank from Burton Bradstock to Bridport Harbour.

"The cliffs are composed of 100 feet of yellow Upper Lias Sands, and a capping of Inferior Oolite not exceeding 10 feet in thickness; also in one place, about the middle of the bay, a thin covering of Fullers' Earth. In descending order the upper 10 feet *represents the thickness* of the Inferior Oolite of the Cotteswolds near Cheltenham (there measuring upwards of 300 feet): these rocks have thinned away in deposition along their line of strike rather than dip, from that area to the coast at Bridport Harbour and Burton Bradstock. The 10 feet of strata above the yellow sands contain the two chief zones of the Inferior Oolite, viz. the *upper* or Parkinsoni (A), here only 4 feet 3 inches thick, but rich in characteristic fossil remains; and below it the Humphresianus zone (B), only 2 feet thick, but equally full of the type fossils (see section). The zone of *Ammonites Murchisoni* appears to be absent, but is replaced by the Jurensis zone and Cephalopoda-bed (C), which unitedly measure only 3 feet 3 inches. These three divisions rest upon the Belemnite

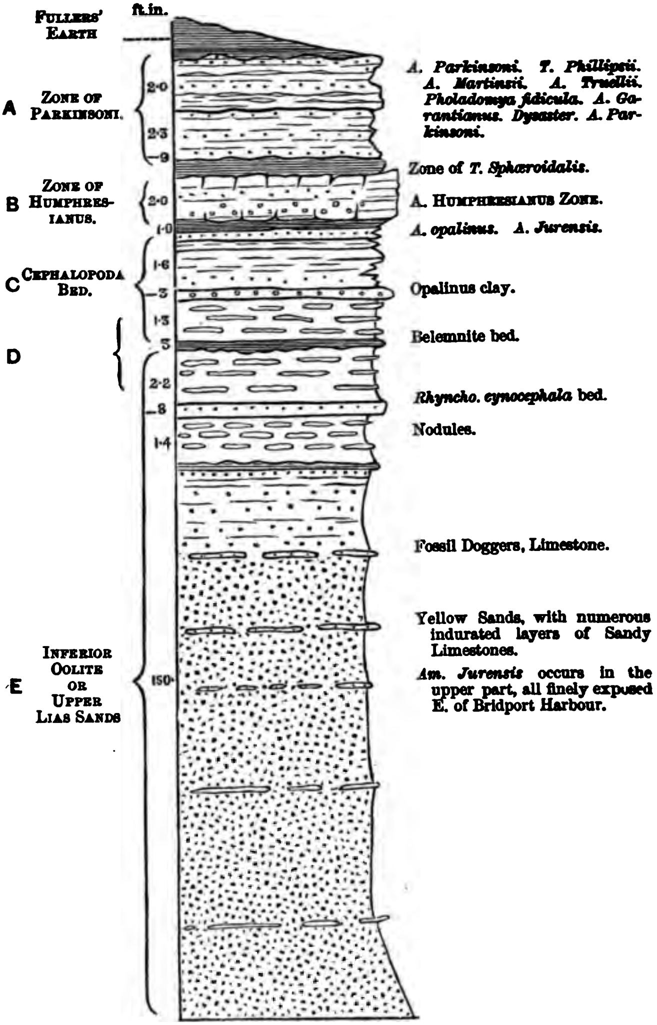
FULLERS' EARTH
ft. in.
A ZONE OF PARKINSONI.
B ZONE OF HUMPHRESIANUS.
C CEPHALOPODA BED.
D
E INFERIOR OOLITE OR UPPER LIAS SANDS
2·0
2·3
–9
2·0
1·0
1·6
–3
1·3
–3
2·2
–8
1·4
150·
A. Parkinsoni. T. Phillipsii. A. Martinsii. A. Truellii. Pholadomya fidicula. A. Garantianus. Dysaster. A. Parkinsoni.
Zone of T. Sphæroidalis.
A. HUMPHRESIANUS ZONE.
A. opalinus. A. Jurensis.
Opalinus clay.
Belemnite bed.
Rhyncho. cynocephala bed.
Nodules.
Fossil Doggers, Limestone.
Yellow Sands, with numerous indurated layers of Sandy Limestones.
Am. Jurensis occurs in the upper part, all finely exposed E. of Bridport Harbour.

Fig. 60. Vertical Section near Bridport Harbour. By R. Etheridge, F.R.S.

bed (D), which is immediately succeeded by the 150 feet of yellow sands (E) (100 feet being visible) composing the cliffs, and which are banded by numerous indurated calcareous sandy layers (Doggers) with a few fossils of Upper Lias types; these sands are in reality 150 feet thick, and rest at Down cliff upon Upper Lias clay. This is not seen east of Bridport Harbour, being below the sea-level.

"It is the upper 10 feet of Inferior Oolite that is of chief interest in this cliff section. About the middle of the bay a downthrow fault shows the Fullers' earth above the two-foot Inferior Oolite Limestone. The two beds comprising the Zone of *Am. Parkinsoni* are 4 feet 6 inches thick, and contain a large assemblage of fossils, amongst which are the following, and may readily be collected: *Ammonites Parkinsoni*, *Am. Martinsi*, *Am. Truellii*, *Am. subradiatus*, *Am. Garantianus*, *Am. Sowerbyi*, *Ostrea flabelloides*, *Lima proboscidea*, *Pholadomya fidicula*, *P. Heraulti*, *Homomya Vezelayi*, *Clypeus altus*, *Collyrites ringens*, *Myoconcha crassa*, *Astarte modiolaris*, *A. quadrata*, *Terebratula Phillipsii*, *T. globata*, *Trigonia costata*, &c., &c.

"The base of the Zone of *Am. Parkinsoni* contains a thin band or 3-inch bed completely made up of *Terebratula globata*, beautifully preserved; this is succeeded by the beds comprising the Zone of *Am. Humphresianus*, about 2 feet thick, and in which the characteristic *Ammonite* abounds, associated with *Astarte modiolaris*, *Myacites Jurensis*, &c. Argillaceous iron nodules occur at the base and determine the line of division between the Zones of *Am. Humphresianus* and that of *Am. Jurensis*, which shows a denuded surface and slight unconformity. The five Jurensis beds measure 4 feet 3 inches. The upper 1 foot contains *Am. Jurensis*, *Am. opalinus*, and *Am. variabilis*, *Rhynchonella cynocephala* and *Pecten barbatus*, succeeded by a sandy bed, 18 inches thick, containing *Am. opalinus*, *Myacites unionides* and *Lyssianassa V. Scripta*, &c. This bed rests upon a clay stratum 3 inches in thickness, containing *Am. opalinus*; 18 inches below this are numerous Belemnites in a thin bed resting upon the yellow Upper Lias sands, which, as before stated, measure 150 feet when all seen, and are the equivalent of the Mitford and Yeovil Sands. Huge blocks, made up of the three zones, and which have fallen from the summit of the cliff, strew the foreshore about the middle of the bay, and in them the entire history of the deposition of the Lower Oolites may here be studied and determined."—R. E.

APPENDIX.

MARINE FAUNA OF THE COAST OF DORSET

That have come under my observation; chiefly from Weymouth Bay and the Sea around Portland.

MOLLUSCA.

Named in accordance with 'British Conchology,'
by Dr. J. Gwyn Jeffreys, F.R.S.

The greater portion of the list is made up of deep-water species, only to be procured by dredging.

Montagu, in his *Testacea Britannica*, 1803, refers several species to the coast of Weymouth, on the information of Mr. Bryer, that in no authenticated instance have since been found either here or on any other part of the British coast. Some of these are well-known West Indian species; but Montagu having regarded them as native, they have been inserted in the Pulteney Catalogue,* as well as in other publications; but in the 'British Mollusca,' by Forbes and Hanley, as also in Dr. Jeffreys' later work, they are considered as exotic, and accordingly expunged from the list of British shells.

The common shells are denoted by the prefix 1; the figure 2 denotes those which are less common, and 3 those which are rare.

This does not, however, indicate their general rarity, but only as applied to Weymouth, and even there is not permanent. From local causes, shells change their ground, and for a time disappear.

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* A Catalogue of the Natural History of the County of Dorset, by Sir W. Pulteney, F.R.S., published 1798, as an appendix to Hutchins' 'History of Dorset,' 2nd edition. The above catalogue, though imperfect when compared with more recent observations, contains much original and *valuable* information.

Bivalves.

1 Anomia ephippium.
2 „ aculeata.
3 „ patelliformis.
1 Arca lactea.
3 Argiope lunifera.
3 „ capsula (*extremely rare*).
3 Astarte triangularis.
3 Axinus flexuosus.
3 Cardium aculeatum.
2 „ echinatum.
1 „ edule, var.
1 „ exiguum.
2 „ fasciatum.
2 „ Norvegicum.
2 „ nodosum.
2 „ tuberculatum.
2 Ceratisolen legumen.
3 Chiton cancellatus.
1 „ cinereus.
3 „ discrepans.
2 „ fasicularis.
3 „ gracilis.
3 „ lævis.
1 Corbula gibba.
3 „ v. rosea.
3 Crenella rhombea.
2 Cyprina Islandica.
2 Cyamium minutum.
3 Cochlodesma pretenue.
3 Diplodonta rotundata.
3 Donax politus.
1 „ vittatus.
3 Galeomma Turtoni.
2 Gastrochæna modiolina.
3 Gastrana fragilis?
2 Kellia suborbicularis.
1 Lasea rubra.
3 Leda caudata.
3 Lepton squamosum.
„ Clarkiæ.
„ nitidum, v. convexum.
3 Loripes (leucoma) lacteus.
2 Lucinopsis undata.
2 Lucina borealis.
3 Lyonsia Norvegica.
2 Lutraria elliptica.
3 „ oblonga.
3 Lima Loscombii.
2 Mactra elliptica.
3 „ solida.
2 „ truncata.
2 „ subtruncata.
1 „ stultorum.
2 „ v. cinerea.
3 Modiolaria costulata.
2 „ discors.
2 „ marmorata.
3 Montacuta ferruginosa.
3 „ substriata.
3 „ bidentata.
2 Mya truncata.
2 „ arenaria.
2 Mytilus Adriaticus.
2 „ barbatus.
1 „ edulis and var.
3 „ modiolus.
3 „ phaseolinus.
1 Nucula nucleus.
2 „ v. radiata.
3 „ nitida.
1 Ostrea edulis.
3 Pandora inæquivalvis.
2 „ var. obtusa.
1 Pecten maximus.
1 „ opercularis.
2 „ v. lineatus.

2 Pecten pusio.
2 „ tigrinus.
3 „ v. costata.
1 „ varius.
1 Pectunculus glycimeris
2 Pholas candida.
2 „ dactylus.
2 „ parva.
3 Pholadidea papyracea.
2 Pinna rudis.
3 Psammobia costulata.
2 „ Ferroensis.
3 „ tellinella.
1 „ vespertina.
1 Saxicava rugosa.
2 „ v. arctica.
3 Solecurtus antiquatus.
3 „ coarctatus.
1 Solen ensis.
2 „ pellucidus.
1 „ siliqua.
2 „ vagina.
2 Scrobicularia alba.
3 „ prismatica.
1 „ piperata.
1 „ tenuis.
3 Sphænia Binghami.
3 Tapes aureus.
2 Tapes decussatus.
1 „ pullastra.
2 „ v. perforans.
1 „ virgineus.
2 Tellina balthica.
2 „ crassa.
2 „ donacina.
1 „ fabula.
2 „ squalida.
1 „ tenuis.
2 Teredo navalis.
2 „ Norvegica.
2 „ megotara.
3 Thracia convexa.
3 „ distorta.
3 „ papyracea.
3 „ villosiuscula.
3 „ pubescens.
2 Venus casina.
2 „ exoleta.
2 „ fasciata.
1 „ ovata.
1 „ gallina.
2 „ lincta.
3 „ verrucosa.
2 Venerupis irus.
2 Xylophaga dorsalis.

Univalves.

3 Aclis ascaris.
3 „ unica.
2 Acera bullata.
3 Actæon tornatilis.
3 Adeorbis subcarinatus.
2 Aplysia punctata.
2 Aporrhais pespelicani.
3 Assiminea littorea.
2 Barleeia rubra.
1 Buccinum undatum.
2 Bulla hydatis.
2 Capulus Hungaricus.
1 Calyptræa chinensis.
3 Cæcum glabrum.
2 „ trachea.
1 Cerithium reticulatum.
3 „ adversum.
3 Cerithiopsis tuberculare.
2 Cyclostrema serpuloides.
2 „ Cutlerianus.

2 Clycostrema nitens.
2 Cyprea Europæa.
3 Cylichna cylindracea.
2 ,, obtusa.
2 Dentalium entalis.
3 ,, tarentinum.
3 Defrancia gracilis.
3 ,, linearis.
3 ,, purpurea.
2 Emarginula fissura.
2 ,, rosea.
3 Eulimella acicula.
3 Eulima bilineata.
2 ,, polita.
3 ,, subulata.
3 ,, distorta.
2 Fissurella græca.
2 Fusus antiquus.
2 ,, gracilis.
2 Helcion pellucidum.
2 ,, v. lævis.
3 Homalogyra atomus.
3 ,, rota (*extremely rare*).
1 Hydrobia ulvæ.
1 ,, ventrosa.
3 Jeffreysia opalina.
2 Lacuna crassior.
2 ,, divaricata.
2 ,, pallidula and var.
2 ,, puteolus.
2 Lamellaria perspicua.
2 Lachesis minima.
1 Littorina litorea.
1 ,, neritoides.
1 ,, obtusata.
1 ,, rudis.
2 ,, v. patula.
2 ,, v. tenebrosa.
3 Marginella lævis.
1 Melampus bidentatus.
1 ,, v. alba.
2 Melampus myosotis.
3 Murex corallinus.
2 ,, erinaceus.
2 Nassa incrassata.
2 ,, pygmea.
1 ,, reticulata.
2 Natica Alderi.
2 ,, catena.
2 Otina otis.
3 Ovula patula.
2 Odostomia acuta.
3 ,, conoidea.
3 ,, decussata.
3 ,, diaphana.
3 ,, fenestrata.
3 ,, insculpta.
3 ,, interstincta.
3 ,, Lukisi.
3 ,, lactea.
3 ,, pallida.
3 ,, plicata.
3 ,, rufa.
3 ,, spiralis.
3 ,, turrita.
3 ,, unidentata.
1 Patella vulgata.
2 ,, v. athletica.
2 Philine aperta.
3 ,, catena.
3 ,, punctata.
3 Pleurobranchus membranaceus.
3 ,, plumula.
,, var. alba.
3 Pleurotoma costata.
2 ,, levigata.
3 ,, nebula.
2 ,, rufa.
3 ,, striolata.
3 ,, septangularis.
3 ,, turricula.
2 Phasianella pulla.

1 Purpura lapillus.
3 Rissoa cancellata.
1 „ cingillus.
1 „ v. rupestris.
1 „ costata.
3 „ costulata.
2 „ fulgida.
2 „ inconspicua.
2 „ v. variegata.
1 „ membranacea.
3 „ proxima.
1 „ parva.
1 „ v. interrupta.
1 „ punctura.
2 „ striata.
„ striatula.
2 „ semistriata.
3 „ violacea.
2 Scalaria communis.
3 „ clathratula.
2 „ Turtoni.
3 Skenea Cutleriana.
2 Skenea planorbis.
2 Scaphander lignarius.
2 Tectura virginea.
1 Trochus cinerarius.
2 „ exasperatus.
2 „ granulatus.
2 „ lineatus.
2 „ magus.
2 „ Montacuti.
2 „ striatus.
1 „ tumidus.
1 „ umbilicatus.
1 „ zizyphinus.
2 „ v. Lyonsii.
1 Turritella terebra.
1 Truncatella Montagui.
3 Trophon muricatus.
3 Utriculus hyalinus.
1 „ obtusus.
2 „ truncatulus.
2 Velutina lævigata.

CEPHALOPODA.

1 Loligo vulgaris (Squid), *Lam.*
2 „ media, *Lin.*
2 Octopus vulgaris, *Lam.*
1 Sepia officinalis, *Lim.*
2 „ Rondoleti, *Leach.*

ECHINODERMATA.

Named from "Forbes' History of British Starfishes."

Starfishes.

Ophiura texturata.
„ albida.
Ophiocoma rosula (com. Brittle-Star).
„ neglecta.
„ granulata.
„ bellis?
Uraster rubens.

Cribella oculata.
Solaster papposa.
Palmipes membranaceus.
Asterias aurantiaca.

Echini.

Echinus sphæra.
„ miliaris (common).
Echinocyamus pusillus.
Spatangus purpureus.
Amphidotus cordatus.

Among the rarer objects found on the Weymouth coast is the *Comatula rosacea* (Rosy Feather-Star) or *Pentacrinus Europæus*, Fleming. This remarkable creature is in its earlier stage of existence a stalked crinoid, having a fixed and basal attachment like one of the fossil Encrinites. It afterwards changes its nature by passing into the "Feather-Star," when it is capable of locomotion. In this state it might be taken for the common "Brittle-Star," from which, however, it differs:—1st. In having ten arms—or rather five bifurcated arms. 2nd. A cup-shaped base, sharply convex on one side, and concave on the other. In swimming, its motion resembles that of the large Medusæ (Jelly-fish) and is effected by advancing the arms alternately, five at a time. In its star-like form it is a beautiful object, of deep rose colour; it is of rare occurrence, and has not before been recorded as found on the Dorsetshire coast.

LIST OF LAND AND FRESH-WATER SHELLS

From the neighbourhood of Weymouth.

Named after the 'British Conchology,' by Dr. Jeffreys, F.R.S.

Sphærium corneum.
„ var. lacustre.
Pisidium amnicum.
„ var. pulchella.
„ pusillum.
„ var. obtusalis.
„ roseum.
Anodonta cygnea.

Neritina fluviatilis.
Bythinia tentaculata.
Hydrobia similis.
„ ventrosa.
Valvata piscinalis.
„ cristata.
Planorbis albus.
„ complanatus.

Planorbis contortus.
„ spirorbis.
„ nitidus.
„ nautileus.
„ vortex.
Physa fontinalis.
„ hypnorum.
Limnæa auricularia.
„ var. acuta.
„ pereger.
„ palustris.
„ stagnalis.
„ truncatula.
„ glabra.
Ancylus fluviatilis.
„ lacustris.
Arion ater.
„ hortensis.
Limax agrestris.
„ arborum.
„ flavus.
Succinea putris.
Vitrina pellucida.
Helix aculeata.
„ aspersa.
„ cantiana.
„ concinna.
„ caperata.
„ ericetorum.
„ fusca.
„ fulva.
„ hispida.
„ lapicida.
Helix nemoralis.
„ var. hortensis.
„ „ hybrida.
„ „ pygmea.
„ pulchella.
„ var. costata.
„ rufescens.
„ rotundata.
„ virgata.
„ var. carinata.
Zonites alliarius.
„ crystallinus.
„ excavatus.
„ cellarius.
„ nitidus.
„ purus.
„ radiatulus.
Bulimus acutus.
„ obscurus.
Pupa secale.
„ umbilicata.
„ marginata.
Vertigo antivertigo.
„ edentula.
„ pygmea.
Balea perversa.
Clausilia rugosa.
„ laminata.
Cochlicopa tridens.
„ lubrica.
Achatina acicula.
Carychium minimum.
Cyclostoma elegans.

Bulimus acutus has a congenial habitat on the sandy banks between Ferry Bridge and Portland; and the small *Helix caperata*, in like numbers covers the Downs and grassy lands of Portland. A writer in 'Blackwood,' in an article on the South Down breed of sheep, attributes the quality of their mutton, as also that of the Portland sheep, to their feeding on the latter species.

LIST OF FERNS GROWING IN THE NEIGHBOURHOOD OF WEYMOUTH.

The nomenclature is that of 'Bentham's Handbook of British Flora.'

Blechnum spicant, Roth.—Hard Fern. Common in hedges and woods.

Pteris aquilina, L.—Eagles' Wing or Common Brake. Common.

Polypodium vulgare, L. Portland. (Common Polypody.)

„ *phegopteris*, L.—Beach Fern. Heffleton Woods, *rare.*

Cystoperis fragilis, Bernh.—Brittle Bladder Fern. Not uncommon.

Aspidium aculeatum, L.—Prickly Fern. Common in hedges.

„ *angulare*—Angular Shield Fern.

„ *Thelypteris*, Sw.—Marsh Fern. Wool Heath.

„ *spinulosum* (*Fœnescii*), Sw.—Soft Prickly Shield Fern. In woods N.E. of Weymouth.

Aspidium cristatum (*dilatata*), Sw.—Soft Prickly Shield Fern. In woods N.E. of Weymouth.

Aspidium rigidum, Sw.—Rigid Fern. On the road to Bere.

„ *filix-mas*, Sw.—Male Fern. Common. Portland.

„ „ *var. affinis*, Sw., *f. m.*, *rare.*

Polypodium alpestre, Hoppe. E. Lulworth, *rare.*

Asplenium filix-fœmina, Bernh.—Lady Fern. Common.

„ *marinum*, L.—Sea Spleenwort. Portland and Lulworth, *rare.*

Asplenium trichomanes, L.—Maidenhair Spleenwort. Portland and Bindon Abbey. Common.

Asplenium Ruta-muraria, L.—Wall Rue Spleenwort. Portland and Wool. Abundant.

Scolopendrium vulgare, Sw.—Hart's Tongue Fern. On "Look out" and Portland.

Ceterach officinarum, Wild.—Scaly Spleenwort. Portland and Wool, *rare.*

Botrychium lunaria, Sw.—Moonwort. *Rare.*

Ophioglossum vulgatum, L.—Adder's Tongue. Bindon Abbey.

Osmunda regalis, L.—Flowering Fern. Bindon Abbey and Wareham.

Cystopteris montana, Bernh.—Mountain Fern. Wool and Portland, *rare.*

RARER PLANTS TO BE OBSERVED NEAR WEYMOUTH.

Adonis autumnalis—Portland.
Arabis hirsuta—Portland.
Asperula cynanchica—Lulworth.
Aster tripolium—Salt Marshes.
Atriplex portulacoides—Marshes by Backwater.
    „ *Babingtonii*—Shores.
    „ *littoralis*—Chesil Bank.
Artemisia absinthium—Portland.
Alopecurus bulbosus—Salt Marshes.
Ammophila arundinacea—Sandy Shore.
Avena fatua—Fields and Cliffs.
Anthyllis vulneraria—Cliffs.
Anthemis nobilis—Lodmoor.
Bupleurum tenuissimum—Lodmoor, &c.
Borago officinalis—Portland.
Beta maritima—Salt Marshes, Fleet.
Brachypodium pinnatum—Cliffs (plentiful).
Cochlearia danica—Chesil Beach.
Cakile maritima—Sandy Shore.
Carduus nutans (white flowers)—Portland.
    „ *marianus*—Portland.
    „ *palustris*—Portland.
    „ *tenuiflorus*—Portland.
Cichorium intybus—Cornfields and Roadsides.
Conyza squarrosa (*Inula Conyza, D. C.*)—Portland.
Campanula glomerata—Road to Dorchester.
    „ *trachelium*—Lulworth.
    „ *hybrida*—Portland.
Convolvulus soldanella—Chesil Bank.
Chenopodium maritimum—Salt Marshes.
    „ *fruticosum*—Chesil Bank.
    „ *ficifolium*—Near Backwater.
Carex arenaria—Near Ferry Bridge.
    „ *binervis*—Heaths.
    „ *cæspitosa*—Heaths.
    „ *distans*—Portland.
    „ *divisa*—Backwater.
    „ *flava*—Heaths.

Carex pulicaris—Heaths.
  „ *pendula*—Abbotsbury, E. of Swanery.
  „ *riparia*—Lodmoor.
  „ *stellulata*—Heaths.
Crithmum maritimum—Chesil Bank.
Diplotaxis muralis—Waste places.
Eryngium maritimum—Chesil Bank.
Erythræa pulchella—Portland, &c.
Erigeron acre—Portland.
Erodium maritimum—Portland.
Euphorbia paralias—Chesil Bank.
  „ *Portlandica*—Portland, &c., Chesil Bank.
  „ *amygdaloides*—Portland.
Eriophorum polystachyum—Portland, near Lighthouse.
Fumaria capreolata—Portland.
Fedia auricula (L.) (Valerianella auricula, D. C.)—Portland.
Filago (?)—Langton Herring (?)
Festuca bromoides—Backwater Cliffs.
  „ *uniglumis*—Road by Chesil Bank, &c.
Glaucium luteum—Stony Beach.
Geranium lucidum—Portland.
  „ *columbinum*—Portland.
Gentiana amarella—Road to Dorchester.
Galeopsis ladanum—Portland.
Glaux maritima—Marshes near Backwater.
Gastridium lendigerum—Backwater Cliffs, &c.
Hyoscyamus niger—Chesil Bank and Lulworth.
Hordeum maritimum—Backwater Lanes.
  „ *pratense*—Fields and Cliffs (abundant).
Hippocrepis comosa—Roadside near Fleet.
Iris fœtidissima—Hedges (frequent).
Iuncus acutus—Shore of Backwater.
  „ *compressus*—Salt Marsh.
  „ *Gerardi*—Shore of Backwater.
  „ *maritimus*—
Luzula multiflora—Heaths.
Linum angustifolium—Backwater and Ferry Bridge.
Lathyrus aphaca—Portland, Wyke.
  „ *nissolia*—E. of Sandsfoot Castle.
Linaria spuria—Lodmoor—Radipole.
  „ *elatine*—Fields (rare).

Lathyrus maritimus (Sea Pea)—Chesil Bank.
Medicago maculata—Cliffs, &c.
„ *denticulata*—Cliffs, &c.
Mercurialis annua—Waste ground.
Obione portulacoides—Portland.
Orobanche elatior—Near Dorchester.
„ *minor*—Portland.
Onobrychis sativa—Railway slopes.
Œnanthe pimpinelloides—Meadows, &c. (frequent).
„ *lachenalii*—Lodmoor.
Papaver somniferum—Near Lulworth.
„ *hybridum*—Wyke.
Pisum maritimum—Chesil Bank.
Petroselinum segetum—Hedges.
Pastinaca sativa—Fields and roadsides.
Prenanthes muralis—Portland.
Pyrethrum maritimum—Salt Marshes.
Plantago maritima—Salt Marshes, Backwater.
Phleum arenarium—Sandy Shore.
Poa distans—Salt Marshes, Backwater.
„ *maritima*—Salt Marshes, Backwater.
„ *procumbens*—Salt Marshes, Backwater.
„ *rigida*—Dry places.
Ruscus aculeatus—Roadside near Broadway.
Rosa spinosissima—Portland.
Rubia peregrina—Portland.
Rumex pulcher—Roadsides.
Ruppia maritima—Salt Marshes, Lodmoor.
Rottbollia incurvata—Salt Marshes (abundant).
Senebiera coronopus—Shores.
„ *didyma*—Shores.
Silene anglica—Lodmoor.
„ *maritima*—Portland.
Sison amomum—Hedges (frequent).
Scabiosa columbaria—Chalk Downs.
Senecio erucifolius—Backwater (common).
„ *sylvaticus*—Cliffs, Backwater.
Silaus pratensis—Moist Meadows (frequent).
Smyrnium olusatrum—Cliff near the Pier.
Solidago virga-aurea—Portland.
Salsola Kali—Sands, Ferry Bridge.

Salicornia herbacea—Marshes, Backwater.
Scirpus maritimus—Near Radipole, &c.
„ *savii*—Portland.
„ *Tabernæmontanæ*—Portland (near Lighthouse).
Trifolium fragiferum—
„ *filiforme* (*rare*)—
„ *maritimum*—Cliffs, Backwater.
„ *ornithopodioides*—Chesil Bank and Portland.
„ *scabrum*—Sandy Shore.
Torilis infesta—Roadsides.
Triglochin maritimum—Marshes, Radipole.
Triticum loliaceum—Roads near Sandsfoot.
„ *junceum*—Sandy Coast, Ferry Bridge.
Thesium linophyllum—Cliffs by Sandsfoot.
Vicia tetrasperma—Backwater Shore.
„ *lævigata*—Radipole.
„ *gracilis*—Cornfields, Portland.
„ *angustifolia*—Cliffs near Sandsfoot.
„ *lutea*—Cliffs, and Lodmoor.
Zannichellia palustris—Salt Marshes.

In the Island of Portland the root of the common *Arum maculatum* is prepared and eaten, and a good quantity was at one time sold, under the name of Portland arrowroot. Since the reduction in the price of the arrowroot of commerce, it has been but little used.

Crithmum maritimum.—On the Chesil Bank, and on the cliffs at Portland, where it is a herb in much request for pickling.

Manuscript Note of Professor E. Forbes.

VARIETIES OF VIOLA CANINA OBSERVED IN PORTLAND.

1. Large normal form in bushy places. Flowers very purple—sepals lanceolate—spurs rather stout—palea purple—radical leaves large, long, slender: all leaves more or less slightly hairy.

2. Smaller form. Similar, but more contracted—leaves very slightly hairy—cordate—radical leaves not conspicuously large—spurs large, pale, rarely purple.

3. Small cæspetose. Flowers very large in proportion to leaves—spurs mostly large—purple-blue—purple rarely, or often yellowish or white—leaves all small, except radicals—smooth crenulate.

LIST OF REMAINS DISCOVERED IN NEIGHBOURHOOD OF VERNE HILL, PORTLAND.

Kindly communicated by Capt. Mascall, Royal Engineers.

A.—*Within the Entrenchment on the upper portion of the West slope of the Verne.*

1. Upper portion of skull found with skeleton much decayed, enclosed within a kist of stone slabs placed on edge, and covered with similar slabs.
2. Lower jaw-bone and one thigh-bone, found within the casing similar to that referred to in No. 1, A. At the side of this coffin was a similar one, apparently that of an infant.
3. Broken pieces of pottery found in the neighbourhood of the above.
4. Flint instrument found in the eastern parapet of entrenchment, near S.W. flank.
5. Kimeridge Clay shale used as the lining of a grave.
6. Ball of chert or dark flint used as a matrix for forming flint instruments.

B.—*Top of Verne Hill.*

1. Large urn of burnt clay, found resting on its side, on the breast-bones of a skeleton, which was found with two others within one stone casing, composed of slabs of an upper Portland bed, which slabs were placed together in the same way as for the coffins in western entrenchments before mentioned, within the urn containing charcoal.
2. Copper stirrups four or five feet below the surface.

C.—*South slope of Verne Hill near flank of S.E. Demi-Bastion at top of Escarpment.*

1. Skull of ox found within a circular dry stone wall, about five feet in height, the circle six feet in diameter; and other bones much decayed; also a large quantity of ashes.
2. *Disc* of Kimeridge Clay shale.

3. Finger-bone with spiral ring of bronze.
4. Gold coin, 97 grains, Gaulish type. Copied from a stater of Philip of Macedon. Obverse a "head of Apollo"; *reverse* Chariot commemorative of victory at Olympic games.

D.—*East, between Verne Hill and the Sea.*

1. Spearhead found in débris of cliff four feet below surface.

E.—*North Common, below Verne Hill.*

1. Skull with entire skeleton, enclosed in loose slabs of shale, placed on edge, and covered by similar slabs.
2. Iron nails found within the stone casing, apparently used for fastening an inner wooden coffin of which no other trace remains.
3. Skull found in position similar to above, where several others were found, the bodies lying east and west.
4. Iron tool supposed to have been used in stone-dressing, a stone coffin having been discovered close to them.
5. Copper coins (Antoninus) found near No. 4, two feet below the surface.
6. Enamelled brooch or clasp near No. 5.
7. Small disc of burnt clay perforated, apparently a stand for a vase with pointed base.
8. Small bronze ring in an excavation on North Common.
9. Small vase of sun-dried clay (lathe-turned).
10. Cap of sun-dried clay, shaped with head.
11. Broken vase.
12. Cut portions of deer-horns found near No. 4.
13. Bullock's horn.
14. Two copper coins.
15. Lead-coated shot, found 5th June, 1865.
16. Iron shot.
17. Circular stone (quoit ?), indurated chalk.
18. Coin, silver penny, Henry III., Terre le Chaunier, 1222.

N.B.—Nos. 5 to 18 were found from two to four feet below the surface in excavating for drains on the North Common.

F.—*S.E. Glacis, near Hut.*

1. Black-ware urn 6 inches high.

2 and 3. Flat saucers.

4. Knife.
5. Skull with other portions of skeleton found in a kist of slabs of Portland Stone, about three feet below the surface, in a deposit of Drift-earth.
6. Part of a speculum or mirror, bronze gilt, found with bones in S.E. glacis about 1878, near F 8.
7. Flint arrow-heads, &c., found in an ancient "Midden" with large quantities of cockle and limpet shells, by side of road to Verne from Fortune's Well, in the top of drift, near S.W. glacis.
8. Skull found with other bones on S.E. glacis in a kist.
9. Boars' tusks and bone implements found in Midden on Verne road.

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